SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

FRIDAY, OCTOBER 10, 1902.

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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

JOHN WESLEY POWELL.

JOHN WESLEY POWELL was born March 24, 1834, at Mount Morris, New York. He died September 23, 1902, at his summer home in Haven, Maine. He was married in 1862 to Emma Dean, of Detroit. His wife and daughter, an only child, survive him.

His parents were English, having reached this country only a few months before his birth. His father was a Methodist preacher and soon removed from New York, living successively in Ohio, Wisconsin and Illinois. His father's occupation took him much from home, and upon the son, while yet a boy, devolved the duty of conducting the farm from which the family derived its principal support. Powell's early schooling was that ordinarily obtainable in a rural community. His scientific bent was acquired by association with an old man by the name of Crookham, and studies in natural history were begun at an early age. His later education was largely independent of schools, but he attended Jacksonville College for a short time, and was at Oberlin two years pursuing a special course. In early manhood he supported himself by teaching, being at the same time a hard student and pursuing natural history studies with enthusiasm. He traversed portions of Wisconsin, Illinois, Iowa and Missouri on foot. He made a voyage of the Mississippi River

in a skiff, starting from the falls of St. Anthony; a voyage of the Ohio from Pittsburg, and a voyage of the Illinois from Ottawa. In these various excursions he was a collector of plants, shells, minerals and fossils, and these collections brought him into relation with various colleges of Illinois. At the outbreak of the Civil War he enlisted in the Twentieth Regiment of Illinois volunteers, and abruptly changed the course of his studies to military science. His successive commissions ranged from second lieutenant to colonel, but the rank of major gave the title by which he was known colloquially in later years. His service was chiefly with artillery, but some of his most important work was of a character commonly assigned to engineer officers. In the battle of Shiloh he lost his right arm, and the resulting physical disability affected his life in important ways. On the one hand, the wounded arm caused him at various periods much pain, and thus weakened an exceptionally strong constitution. On the other, he was led in early manhood to employ an amanuensis, and the resulting freedom from the mechanical factor in writing was a distinct advantage to his literary work.

At the close of the war he promptly returned to civil life, dropping the study of military science as abruptly as he had begun it. A business opening, and an attractive opportunity to enter political life, were declined in favor of scientific work. He became professor of geology at Bloomington, Illinois, and lecturer on geology at Normal, Illinois. In 1867 he organized and led the first important geological excursion of American students, taking a party of sixteen to the mountain region of Colorado. This was before the building of transcontinental railways, and the journey across the plains was long. He remained among the mountains as an explorer after the party had returned east, and in the following years organized a second expedition, with geologic and geographic exploration and research as its chief objects. The necessary funds were furnished by various educational institutions in Illinois and by the Smithsonian Institution, and Congressional authority was obtained for supplying the party with provisions from the military posts of the West. His expedition wintered west of the Rocky Mountains in the valley of White River, and the long period thus spent in a permanent camp was occupied in the scientific study of Indians. In the following spring four boats were brought from Chicago to the point where the newly constructed Union Pacific Railway crossed Green River, and a party was organized for the exploration of the canyons of the Green and Colorado rivers. When this work was begun it was known that the rivers here descend in a distance of 700 to 1,000 miles through the vertical space of 5,000 feet, coursing most of the way between unscalable walls, but the nature of the rapids, cascades and cataracts by which the water falls from the upper to the lower level was altogether unknown. The undertaking was therefore of phenomenal boldness and its successful accomplishment a dramatic triumph. It produced a strong impression on the public mind and gave Powell a national reputation which was afterwards of great service, although based on an adventurous episode by no means essential to his career as an investigator.

The voyage through the canyons was a reconnaissance in an unexplored area and led to the organization of a geographic and geologic survey, for which appropriation was asked and obtained from Congress, the work being initially placed under the supervision of the Smithsonian Institution. By the advice of Professor Henry the gathering of ethnologic data was made a leading function of the organization. In 1869

a boat party began a second voyage through the canyons, the plan being to spend two years in their mapping, and land parties were at the same time organized to cooperate with them. The river was abandoned as a base of operations in the middle of the second season, but the land work continued, with progressive development of plan, for a period of ten years. About the middle of this period the study of the problem of the utilization of the arid region through irrigation and otherwise became a function of the organization, and a special investigation was made of the water supply of the territory of Utah.

Of parallel growth were the surveys developed under the initiative of Dr. Hayden, Clarence King and Lieutenant Wheeler. Their functions were similar and, with the exception of the work by King which had a definite limit, their ambitions included the exploration and survey of all the western domain of the United States. They thus became rivals and there was need of reorganization. After unsuccessful efforts to arrange for the partition of the field and friendly cooperation between the different corps, Powell advocated their merging into a single bureau of the Interior Department, and it was largely through his initiative that the work was finally reorganized in 1879. The Powell, Hayden and Wheeler surveys were abolished and the present U. S. Geological Survey created, Mr. King becoming by presidential appointment its first director. At the same time the Bureau of Ethnology was created to carry forward the ethnologic work, and of this Powell became director. The Geological Survey was made a bureau of the Interior Department, and the Bureau of Ethnology was attached to the Smithsonian Institution.

The study of water supply in relation to irrigation led to the conclusion that the land laws of the United States were ill adapted to the conditions obtaining in all the drier portion of the country, and Powell became much interested in the legislative problems thus arising. Partly at his instance a commission was appointed to codify the land laws and recommend such modifications as seemed to be required. Powell gave much of his time for two years to the work of this commission and a comprehensive report was prepared, which however led to no legislation.

In 1881 Mr. King resigned the directorship of the Geological Survey and Powell was immediately named as his successor. He retained the direction of the Bureau of Ethnology and conducted both bureaus until 1894, when he resigned from the Geological Survey. During his administration the work of the Survey was greatly enlarged, especially in its geographic branch, and the investigation of water supply with special reference to utilization for irrigation was added to its functions.

In the last years of his life Powell practically relinquished administrative responsibility, entrusting the management of the Bureau of Ethnology to his principal assistant, Mr. McGee, and devoting his time to personal studies which passed gradually from anthropology into the fields of psychology and general philosophy.

In summarizing the results of his active life it is not easy to separate the product of his personal work from that which he accomplished through the organization of the work of others. He was extremely fertile in ideas, so fertile that it was quite impossible that he should personally develop them all, and realizing this he gave freely to his collaborators. The work which he inspired and to which he contributed the most important creative elements, I believe to be at least as important as that for which his name stands directly responsible. As he always drew about him the best ability he could command, his assistants were not

mere elaborators, but made also important original contributions, and the ideas which he gave the world through others are thus so merged and mingled with theirs that they can never be separated. If we count the inspiration of his colleagues as part of his work of organization then the organization of researches may properly be placed first in the list of his contributions to the progress of science. Other terms of the list pertain to the fields of geology, physical and economic geography, anthropology and philosophy.

The creation of the U. S. Geological Survey belonged to the logic of events and would undoubtedly have taken place within a few years without Powell's assistance, but his active advocacy hastened the change and his ideas had greater influence than those of any other individual in determining the mode of reconstruction of the national scientific work. He was so prominent as a promoter of reorganization that when it had been accomplished he felt that his motives might be impugned if he became a candidate for the directorship of the Survey, and he therefore declined to have his name presented. It is proper to add that the scheme of reorganization which he advocated was not adopted in full. His plan included the organization of three bureaus to conduct investigation in the fields of geology, geography and ethnology, but Congress created only two bureaus, leaving geography without special provision. The work of geographic mapping was taken up by the Geological Survey as a means for providing base maps for the use of geologists, and thus the Survey has become a bureau of geography as well as geology.

Two years later, when Powell succeeded King in the administration of the Geological Survey, he found the subdivision of the work arranged largely on geographic lines. There were branch offices at Denver, Salt Lake City and San Francisco, each in charge of a chief who directed the geologic and topographic work of a large district. For this classification Powell gradually substituted one based upon function, abolishing the districts and separate offices and creating divisions of topography, general geology, and economic geology, coordinate with divisions of paleontology, physics and chemistry. Areal or geographic classification was still used, but was subordinated to a subject classification.

Careful attention was given to the financial system of the bureau, the machinery by which the public funds were paid out and accounted for, and the wisdom of this attention was afterward fully justified. When in later years the affairs of the Survey were subjected to unfriendly and searching investigation the accounts were found in such perfect condition as to elicit the highest praise of the Comptroller of the Treasury, to whom the results of the investigation were finally referred. The reputation of the Survey for good business methods inspired the confidence of legislators and led them to provide for the growth of the bureau, not only by the increase of appropriations for existing functions, but through the gradual enlargement of function. The most important single addition to its duties was that of studying the water supply of the country with reference to various economic problems.

Except for the original suggestion or instruction by Professor Henry, and except for the votes of funds by Congress, the Bureau of Ethnology may be regarded as Powell's creation. Work on American ethnology had previously been discursive, unorganized, and to a large extent dilettanti. He gave to it definite purposes conformable to high scientific standards, and personally trained its corps of investigators. To men who had previously interested themselves in the study of Indians

he gave new methods and a new point of view, and he succeeded in diverting to ethnology men already trained in scientific method by work in other fields of research. He realized, as perhaps few had realized before him, that the point of view of the savage is essentially different from that of the civilized man, that just as his music cannot be recorded in the notation of civilized music, just as his words cannot be written with the English alphabet, so the structure of his language transcends the formulæ of Aryan grammars, and his philosophy and social organization follow lines unknown to the European. He also realized most fully that the savage is the embryo of the man of highest culture, and that the study of savagery is therefore a fundamental contribution to the broadest study of humanity. With these ideas he informed his ethnologic corps, and in consequence of them the organization of the bureau marks the most important epoch in American ethnology.

The same personal influence extended to the work of the Anthropological Society of Washington. Over the proceedings of this society Powell presided for many years, taking part in all its discussions and making it his special function to point out the bearing and relation of each communication to the greater problems and broader aspects of the science. As the bureau was and is a laboratory of ethnology, devoted to the study and record of the character and culture of the fading tribes of North America, so the society, including the same group of students, was and is an arena for the discussion of the broader science of anthropology. I but echo the general sentiment of those students in saying that the high intellectual and scientific plane on which the work of this society is conducted is a result, direct and cumulative, of Powell's influence and example.

Before turning to Powell's direct contributions to science, mention should be made of his studies in biology. In early manhood he was an assiduous collector of plants, fresh-water shells and reptiles, and this work was accompanied by studies in distribution. But the results of such studies do not constitute a contribution to botany and zoology. The work was properly a part of his education, a training in the art of observation, which bore fruit only when his attention was turned to other branches.

His contributions to geology include a certain amount of descriptive work. He published the stratigraphy, structure, and part of the areal geology of the Colorado Plateaus and the Uinta Mountains. In connection with the field studies in these districts he developed a new classification of mountains, by structure and genesis, a structural classification of dislocations, a classification of valleys, and a genetic classification of drainage systems. His classification of drainage recognized three modes of genesis, of which two were new. With the novel ideas involved in the terms 'superimposed drainage' and 'antecedent drainage' were associated the broader idea that the physical history of a region might be read in part from a study of its drainage system in relation to its rock structure. Another broad idea, that since the degradation of the land is limited downward by the level of the standing water which receives its drainage, the types of land sculpture throughout a drainage area are conditioned by this limit, was formulated by means of the word 'base-level.' These two ideas, gradually developed by a younger generation of students, are the fundamental principles of a new subscience of geology sometimes called geomorphology, or physiographic geology.

The scientific study of the arid lands of our western domain in relation to human industries practically began with Powell.

Early in his governmental work he issued a volume on the lands of the arid region, and he continued their discussion in one way or another for twenty years, setting forth the physical conditions associated with aridity, the paroxysmal character of rainfall, the dependence of arable lowlands on the rainfall and snowfall of uplands, and the generous response of the vegetation of arid regions to the artificial application of water. Emphasizing the necessity of irrigation to successful agriculture, he pointed out the need of conserving storm waters by artificial reservoirs, the need of applying new principles in legislation for the regulation of water rights, and the need of a new system of laws for the control of title in arid lands. These ideas when first advanced were the subject of hostile criticism because they antagonized current opinions as to the availability of our western domain for settlement; but he afterward found himself part of a general movement for the intelligent development of the West, a movement whose latest achievement is the so-called reclamation law.

He pointed out also that our land laws did not permit the lean pasture lands of the West to be acquired by private owners in tracts large enough for economic management, and that overstocking and periodic disasters were the logical results of public ownership; and his ideas as to remedial legislation were embodied in the unheeded report to the Public Lands Commission.

In descriptive ethnology Powell's published contributions are meager in comparison with his body of observations and notes. They are comprised in a magazine article on the Mokis, an essay on the Wyandots, and a few myths, chiefly Shoshonian, introduced in various writings for illustrative purposes. In his 'Introduction to the Study of Indian Languages' he gives instructions for American ethnologic observation, covering not only the subject of language, but arts, institutions and mythology. Other writings belong more properly to anthropology, and deal with its broader principles. In a series of essays, designed as chapters of a manual of anthropology but actually published as occasional addresses and never assembled, he points out the lines of evolution in the various fields of human thought and activity, philosophic, linguistic, esthetic, social and industrial. The ground covered by these essays is so broad that a brief summary is impossible. They include the ideas which have directed the work of the Bureau of Ethnology, and they include also much which has found no immediate application, belonging to fields of thought as yet untouched by others. As to their ultimate value future generations must decide, but they stand nearly or quite unique as a comprehensive body of philosophic thought founded on the comparison of aboriginal with advanced culture.

In later years attention was gradually turned from anthropology to psychology and the fundamental concepts of natural philosophy. His interest in these subjects began in early manhood, and they are briefly touched in various writings; but he gave the last eight years of his life almost wholly to their study. Two books were written and a third planned. 'Truth and Error,' which appeared in 1899, treats of matter, motion and consciousness as related to the external universe or the field of fact. 'Good and Evil,' printed as a series of essays in *The Anthropologist* with the intention of eventual assemblage in book form, treats of the same factors as related to humanity or to welfare. The field of the emotions was assigned to the third volume. His philosophy was also embodied in a series of poems, of which only one has received publication.

In much of his scientific writing Pow-

ell's style is terse to a fault. Usually he is satisfied with the simplest statement of his conclusions. Sometimes he adds illustrations. Only rarely does he explain them by setting forth their premises. It has thus happened that some of his earlier work, though eventually recognized as of high importance, was at first either not appreciated or misunderstood. The value of his anthropologic philosophy, though now widely appreciated, was recognized but slowly outside the sphere of his personal influence. His philosophic writings belong to a field in which thought has ever found language inadequate, and are for the present, so far as may be judged from the reviews of 'Truth and Error,' largely misunderstood. Admitting myself to be of those who fail to understand much of his philosophy, I do not therefore condemn it as worthless, for in other fields of his thought events have proved that he was not visionary but merely in advance of his time.

To the nation he is known as an intrepid explorer, to a wide public as a conspicuous and cogent advocate of reform in the laws affecting the development of the arid West, to geologists as a pioneer in a new province of interpretation and the chief organizer of a great engine of research, to anthropologists as a leader in philosophic thought and the founder, in America, of the new régime.

G. K. Gilbert.

THE ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

II.

LIQUEFACTION OF GASES AND CONTINUITY OF STATE.

In these speculations, however, chemists were dealing theoretically with temperatures to which they could not make any but the most distant experimental approach. Cullen, the teacher of Black, had indeed shown how to lower temperature by the evaporation of volatile bodies such as ether, by the aid of the air-pump, and the later experiments of Leslie and Wollaston extended the same principle. Davy and Faraday made the most of the means at command in liquefying the more condensable gases, while at the same time Davy pointed out that they in turn might be utilized to procure greater cold by their rapid reconversion into the aeriform state. Still the chemist was sorely hampered by the want of some powerful and accessible agent for the production of temperatures much lower than had ever been attained. That want was supplied by Thilorier, who in 1835 produced liquid carbonic acid in large quantities, and further made the fortunate discovery that the liquid could be frozen into a snow by its own evaporation. Faraday was prompt to take advantage of this new and potent agent. Under exhaustion he lowered its boiling-point from *minus* 78° C. to *minus* 110° C., and by combining this low temperature with pressure all the gases were liquefied by the year 1844, with the exception of the three elementary gases—hydrogen, nitrogen, and oxygen, and three compound gases—carbonic oxide, marsh gas, and nitric oxide; Andrews some twenty-five years after the work of Faraday attempted to induce change of state in the uncondensed gases by using much higher pressures than Faraday employed. Combining the temperature of a solid carbonic acid bath with pressures of 300 atmospheres, Andrews found that none of these gases exhibited any appearance of liquefaction in such high states of condensation; but so far as change of volume by high compression went, Andrews confirmed the earlier work of Natterer by showing that the gases become proportionately less compressible with growing pressure. While such investiga-

tions were proceeding, Regnault and Magnus had completed their refined investigations on the laws of Boyle and Gay-Lussac. A very important series of experiments was made by Joule and Kelvin 'On the Thermal Effects of Fluids in Motion' about 1862, in which the thermometrical effects of passing gases under compression through porous plugs furnished important data for the study of the mutual action of the gas molecules. No one, however, had attempted to make a complete study of a liquefiable gas throughout wide ranges of temperature. This was accomplished by Andrews in 1869, and his Bakerian Lecture 'On the Continuity of the Gaseous and Liquid States of Matter' will always be regarded as an epoch-making investigation. During the course of this research Andrews observed that liquid carbonic acid raised to a temperature of 31° C. lost the sharp concave surface of demarcation between the liquid and the gas, the space being now occupied by a homogeneous fluid which exhibited, when the pressure was suddenly diminished or the temperature slightly lowered, a peculiar appearance of moving or flickering striæ, due to great local alterations of density. At temperatures above 31° C. the separation into two distinct kinds of matter could not be effected even when the pressure reached 400 atmospheres. This limiting temperature of the change of state from gas to liquid Andrews called the critical temperature. He showed that this temperature is constant, and differs with each substance, and that it is always associated with a definite pressure peculiar to each body. Thus the two constants, critical temperature and pressure, which have been of the greatest importance in subsequent investigations, came to be defined, and a complete experimental proof was given that 'the gaseous and liquid states are only distinct stages of the same condition of matter and are capable of passing into one another by a process of continuous change.'

In 1873 an essay 'On the Continuity of the Gaseous and Liquid State,' full of new and suggestive ideas, was published by van der Waals, who, recognizing the value of Clausius' new conception of the virial in dynamics, for a long-continued series of motions, either oscillatory or changing exceedingly slowly with time, applied it to the consideration of the molecular movements of the particles of the gaseous substance, and after much refined investigation, and the fullest experimental calculation available at the time, devised his well-known Equation of Continuity. Its paramount merit is that it is based entirely on a mechanical foundation, and is in no sense empiric; we may therefore look upon it as having a secure foundation in fact, but as being capable of extension and improvement. James Thomson, realizing that the straight-line breach of continuous curvature in the Andrews isothermals was untenable to the physical mind, propounded his emendation of the Andrews curves—namely, that they were continuous and of S form. We also owe to James Thomson the conception and execution of a three-dimensional model of Andrews' results, which has been of the greatest service in exhibiting the three variables by means of a specific surface afterwards greatly extended and developed by Professor Willard Gibbs. The suggestive work of James Thomson undoubtedly was a valuable aid to van der Waals, for as soon as he reached the point where his equation had to show the continuity of the two states this was the first difficulty he had to encounter, and he succeeded in giving the explanation. He also gave a satisfactory reason for the existence of a minimum value of the product of volume and pressure in the Regnault isothermals. His isothermals, with James Thomson's completion of them, were now

shown to be the results of the laws of dynamics. Andrews applied the new equation to the consideration of the coefficients of expansion with temperature and of pressure with temperature, showing that although they were nearly equal, nevertheless they were almost independent quantities. His investigation of the capillarity constant was masterly, and he added further to our knowledge of the magnitudes of the molecules of gases and of their mean free paths. Following up the experiments of Joule and Kelvin, he showed how their cooling coefficients could be deduced, and proved that they vanished at a temperature in each case which is a constant multiple of the specific critical temperature. The equation of continuity developed by van der Waals involved the use of three constants instead of one, as in the old law of Boyle and Charles, the latter being only utilized to express the relation of temperature, pressure, and volume, when the gas is far removed from its point of liquefaction. Of the two new constants one represents the molecular pressure arising from the attraction between the molecules, the other four times the volume of the molecules. Given these constants of a gas, van der Waals showed that his equation not only fitted into the general characters of the isothermals, but also gave the values of the critical temperature, the critical pressure, and the critical volume. In the case of carbonic acid the theoretical results were found to be in remarkable agreement with the experimental values of Andrews. This gave chemists the means of ascertaining the critical constants, provided sufficiently accurate data derived from the study of a few properly distributed isothermals of the gaseous substance were available. Such important data came into the possession of chemists when Amagat published his valuable paper on 'The Isothermals of Hydrogen, Nitrogen, Oxygen, Ethylene, etc.,' in the year 1880. It now became possible to calculate the critical data with comparative accuracy for the so-called permanent gases oxygen and nitrogen, and this was done by Sarrau in 1882. In the meantime a great impulse had been given to a further attack upon the so-called permanent gases by the suggestive experiments made by Pictet and Cailletet. The static liquefaction of oxygen was effected by Wroblewski in 1883, and thereby the theoretical conclusions derived from van der Waals' equation were substantially confirmed. The liquefaction of oxygen and air was achieved through the use of liquid ethylene as a cooling agent, which enabled a temperature of *minus* 140 degrees to be maintained by its steady evaporation *in vacuo*. From this time liquid oxygen and air came to be regarded as the potential cooling agents for future research, commanding as they did a temperature of 200 degrees below melting ice. The theoretical side of the question received at the hands of van der Waals a second contribution, which was even more important than his original essay, and that was his novel and ingenious development of what he calls 'The Theory of Corresponding States.' He defined the corresponding states of two substances as those in which the ratios of the temperature, pressure, and volume, to the critical temperature, pressure, and volume respectively were the same for the two substances, and in corresponding states he showed that the three pairs of ratios all coincided. From this a series of remarkable propositions were developed, some new, some proving previous laws that were hitherto only empiric, and some completing and correcting faulty though approximate laws. As examples, he succeeded in calculating the boiling-point of carbonic acid from observations on ether vapor, proved Kopp's law of molecular volumes, and showed that at

corresponding temperatures the molecular latent heats of vaporization are proportional to the absolute critical temperature, and that under the same conditions the coefficients of liquid expansion are inversely proportional to the absolute critical temperature, and that the coefficients of liquid compressibility are inversely proportional to the critical pressure. All these propositions and deductions are in the main correct, though further experimental investigation has shown minor discrepancies requiring explanation. Various proposals have been made to supplement van der Waals' equation so as to bring it into line with experiments, some being entirely empiric, others theoretical. Clausius, Sarrau, Wroblewski, Batteli, and others attacked the question empirically, and in the main preserved the co-volume (depending on the total volume of the molecules) unaltered while trying to modify the constant of molecular attraction. Their success depended entirely on the fact that, instead of limiting the number of constants to three, some of them have increased them to as many as ten. On the other hand, a series of very remarkable theoretical investigations has been made by van der Waals himself, by Kammerlingh Onnes, Korteweg, Jaeger, Boltzmann, Dieterici, and Rienganum, and others, all directed in the main towards an admitted variation in the value of the co-volume while preserving the molecular attraction constant. The theoretical deductions of Tait lead to the conclusion that a substance below its critical point ought to have two different equations of the van der Waals type, one referring to the liquid and the other to the gaseous phase. One important fact was soon elicited—namely, that the law of correspondence demanded only that the equation should contain not more than three constants for each body. The simplest extension is that made by Reinganum, in which he increased the pressure for a given mean kinetic energy of the particles inversely in the ratio of the diminution of free volume, due to the molecules possessing linear extension. Berthelot has shown how a 'reduced' isothermal may be got by taking two other prominent points as units of measurement instead of the critical coordinates. The most suggestive advance in the improvement of the van der Waals equation has been made by a lady, Mme. Christine Meyer. The idea at the base of this new development may be understood from the following general statement: van der Waals brings the van der Waals surfaces for all substances into coincidence at the point where volume, pressure, and temperature are nothing, and then stretches or compresses all the surfaces parallel to the three axes of volume, pressure, and temperature, until their critical points coincide. But on this plan the surfaces do not quite coincide, because the points where the three variables are respectively nothing are not corresponding points. Mme. Meyer's plan is to bring all the critical points first into coincidence, and then to compress or extend all the representative surfaces parallel to the three axes of volume, pressure, and temperature, until the surfaces coincide. In this way, taking twenty-nine different substances, she completely verifies from experiment van der Waals' law of correspondence. The theory of van der Waals has been one of the greatest importance in directing experimental investigation, and in attacking the difficult problems of the liquefaction of the most permanent gases. One of its greatest triumphs has been the proof that the critical constants and the boiling-point of hydrogen theoretically deduced by Wroblewski from a study of the isothermals of the gas taken far above the temperature of liquefaction are remarkably near the experi-

mental values. We may safely infer, therefore, that if hereafter a gas be discovered in small quantity even four times more volatile than liquid hydrogen, yet by a study of its isothermals at low temperature we shall succeed in finding its most important liquid constants, although the isolation of the real liquid may for the time be impossible. It is perhaps not too much to say that as a prolific source of knowledge in the department dealing with the continuity of state in matter, it would be necessary to go back to Carnot's cycle to find a proposition of greater importance than the theory of van der Waals and his development of the law of corresponding states.

It will be apparent from what has just been said that, thanks to the labors of Andrews, van der Waals, and others, theory had again far outrun experiment. We could calculate the constants and predict some of the simple physical characteristics of liquid oxygen, hydrogen, or nitrogen with a high degree of confidence long before any one of the three had been obtained in the static liquid condition permitting of the experimental verification of the theory. This was the more tantalizing, because, with whatever confidence the chemist may anticipate the substantial corroboration of his theory, he also anticipates with almost equal conviction that as he approaches more and more nearly to the zero of absolute temperature, he will encounter phenomena compelling modification, revision, and refinement of formulas which fairly covered the facts previously known. Just as nearly seventy years ago chemists were waiting for some means of getting a temperature of 100 degrees below melting ice, so ten years ago they were casting about for the means of going 100 degrees lower still. The difficulty, it need hardly be said, increases in a geometrical rather than in an arithmetical ratio. Its magnitude may be estimated from the fact that to produce liquid air in the atmosphere of an ordinary laboratory is a feat analogous to the production of liquid water starting from steam at a white heat, and working with all the implements and surroundings at the same high temperature. The problem was not so much how to produce intense cold as how to save it when produced from being immediately levelled up by the relatively superheated surroundings. Ordinary non-conducting packings were inadmissible because they are both cumbrous and opaque, while in working near the limits of our resources it is essential that the product should be visible and readily handled. It was while puzzling over this mechanical and manipulative difficulty in 1892 that it occurred to me that the principle of an arrangement used nearly twenty years before in some calorimetric experiments, which was based upon the work of Dulong and Petit on radiation, might be employed with advantage as well to protect cold substances from heat as hot ones from rapid cooling. I therefore tried the effect of keeping liquefied gases in vessels having a double wall, the annular space between being very highly exhausted. Experiments showed that liquid air evaporated at only one fifth of the rate prevailing when it was placed in a similar unexhausted vessel, owing to the convective transference of heat by the gas particles being enormously reduced by the high vacuum. But, in addition, these vessels lend themselves to an arrangement by which radiant heat can also be cut off. It was found that when the inner walls were coated with a bright deposit of silver the influx of heat was diminished to one sixth the amount entering without the metallic coating. The total effect of the high vacuum and the silvering is to reduce the ingoing heat to about three per cent. The efficiency of such vessels depends upon get-

ting as high a vacuum as possible, and cold is one of the best means of effecting the desired exhaustion. All that is necessary is to fill completely the space that has to be exhausted with an easily condensable vapor, and then to freeze it out in a receptacle attached to the primary vessel that can be sealed off. The advantage of this method is that no air-pump is required, and that theoretically there is no limit to the degree of exhaustion that can be obtained. The action is rapid, provided liquid air is the cooling agent, and vapors like mercury, water, or benzol are employed. It is obvious that when we have to deal with such an exceptionally volatile liquid as hydrogen, the vapor filling may be omitted because air itself is now an easily condensable vapor. In other words, liquid hydrogen, collected in such vessels with the annular space full of air, immediately solidifies the air and thereby surrounds itself with a high vacuum. In the same way, when it shall be possible to collect a liquid boiling on the absolute scale at about five degrees, as compared with the twenty degrees of hydrogen, then you might have the annular space filled with the latter gas to begin with, and yet get directly a very high vacuum, owing to the solidification of the hydrogen. Many combinations of vacuum vessels can be arranged, and the lower the temperature at which we have to operate the more useful they become. Vessels of this kind are now in general use, and in them liquid air has crossed the American continent. Of the various forms, that variety is of special importance which has a spiral tube joining the bottom part of the walls, so that any liquid gas may be drawn off from the interior of such a vessel. In the working of regenerative coils such a device becomes all-important, and such special vessels cannot be dispensed with for the liquefaction of hydrogen.

In the early experiments of Pictet and Cailletet, cooling was produced by the sudden expansion of the highly compressed gas, preferably at a low temperature, the former using a jet that lasted for some time, the latter an instantaneous adiabatic expansion in a strong glass tube. Neither process was practicable as a mode of producing liquid gases, but both gave valuable indications of partial change into the liquid state by the production of a temporary mist. Linde, however, saw that the continuous use of a jet of highly compressed gas, combined with regenerative cooling, must lead to liquefaction on account of what is called the Kelvin-Joule effect; and he succeeded in making a machine, based on this principle, capable of producing liquid air for industrial purposes. These experimenters had proved that, owing to molecular attraction, compressed gases passing through a porous plug or small aperture were lowered in temperature by an amount depending on the difference of pressure, and inversely as the square of the absolute temperature. This means that for a steady difference of pressure the cooling is greater the lower the temperature. The only gas that did not show cooling under such conditions was hydrogen. Instead of being cooled it became actually hotter. The reason for this apparent anomaly in the Kelvin-Joule effect is that every gas has a thermometric point of inversion above which it is heated and below which it is cooled. This inversion point, according to van der Waals, is six and three-quarter times the critical point. The efficiency of the Linde process depends on working with highly compressed gas well below the inversion temperature, and in this respect this point may be said to take the place of the critical one, when in the ordinary way direct liquefaction is being effected by the use of specific liquid cooling agents. The success of both processes depends upon working within a certain temperature

range, only the Linde method gives us a much wider range of temperature within which liquefaction can be effected. This is not the case if, instead of depending on getting cooling by the internal work done by the attraction of the gas molecules, we force the compressed gas to do external work as in the well-known air machines of Kirk and Coleman. Both these inventors have pointed out that there is no limit of temperature, short of liquefaction of the gas in use in the circuit, that such machines are not capable of giving. While it is theoretically clear that such machines ought to be capable of maintaining the lowest temperatures, and that with the least expenditure of power, it is a very different matter to overcome the practical difficulties of working such machines under the conditions. Coleman kept a machine delivering air at *minus* 83 degrees for hours, but he did not carry his experiments any further. Recently Monsieur Claude, of Paris, has, however, succeeded in working a machine of this type so efficiently that he has managed to produce one liter of liquid air per horse power expended per hour in the running of the engine. This output is twice as good as that given by the Linde machine, and there is no reason to doubt that the yield will be still further improved. It is clear, therefore, that in the immediate future the production of liquid air and hydrogen will be effected most economically by the use of machines producing cold by the expenditure of mechanical work.

LIQUID HYDROGEN AND HELIUM.

To the physicist the copious production of liquid air by the methods described was of peculiar interest and value as affording the means of attacking the far more difficult problem of the liquefaction of hydrogen, and even as encouraging the hope that liquid hydrogen might in time be employed for the liquefaction of yet more volatile elements, apart from the importance which its liquefaction must hold in the process of the steady advance towards the absolute zero. Hydrogen is an element of especial interest, because the study of its properties and chemical relations led great chemists like Faraday, Dumas, Daniell, Graham and Andrews to entertain the view that if it could ever be brought into the state of liquid or solid it would reveal metallic characters. Looking to the special chemical relations of the combined hydrogen in water, alkaline oxides, acids, and salts, together with the behavior of these substances on electrolysis, we are forced to conclude that hydrogen behaves as the analogue of a metal. After the beautiful discovery of Graham that palladium can absorb some hundreds of times its own volume of hydrogen, and still retain its luster and general metallic character, the impression that hydrogen was probably a member of the metallic group became very general. The only chemist who adopted another view was my distinguished predecessor, Professor Odling. In his 'Manual of Chemistry,' published in 1861, he pointed out that hydrogen has chlorous as well as basic relations, and that they are as decided, important, and frequent as its other relations. From such considerations he arrived at the conclusion that hydrogen is essentially a neutral or intermediate body, and therefore we should not expect to find liquid or solid hydrogen possess the appearance of a metal. This extraordinary prevision, so characteristic of Odling, was proved to be correct some thirty-seven years after it was made. Another curious anticipation was made by Dumas in a letter addressed to Pictet, in which he says that the metal most analogous to hydrogen is magnesium, and that probably both elements have the same atomic volume, so that the density of hydrogen, for this reason, would be about

the value elicited by subsequent experiments. Later on, in 1872, when Newlands began to arrange the elements in periodic groups, he regarded hydrogen as the lowest member of the chlorine family; but Mendeleef in his later classification placed hydrogen in the group of the alkaline metals; on the other hand, Dr. Johnstone Stoney classes hydrogen with the alkaline earth metals and magnesium. From this speculative divergency it is clear no definite conclusion could be reached regarding the physical properties of liquid or solid hydrogen, and the only way to arrive at the truth was to prosecute low-temperature research until success attended the efforts to produce its liquefaction. This result I definitely obtained in 1898. The case of liquid hydrogen is, in fact, an excellent illustration of the truth already referred to, that no theoretical forecast, however apparently justified by analogy, can be finally accepted as true until confirmed by actual experiment. Liquid hydrogen is a colorless transparent body of extraordinary intrinsic interest. It has a clearly defined surface, is easily seen, drops well, in spite of the fact that its surface tension is only the thirty-fifth part of that of water, or about one fifth that of liquid air, and can be poured easily from vessel to vessel. The liquid does not conduct electricity, and, if anything, is slightly diamagnetic. Compared with an equal volume of liquid air, it requires only one fifth the quantity of heat for vaporization; on the other hand, its specific heat is ten times that of liquid air or five times that of water. The coefficient of expansion of the fluid is remarkable, being about ten times that of gas; it is by far the lightest liquid known to exist, its density being only one fourteenth that of water; the lightest liquid previously known was liquid marsh gas, which is six times heavier. The only solid which has so small density as to float upon its surface is a piece of pith wood. It is by far the coldest liquid known. At ordinary atmospheric pressure it boils at *minus* 252.5 degrees or 20.5 degrees absolute. The critical point of the liquid is about 29 degrees absolute, and the critical pressure not more than fifteen atmospheres. The vapor of the hydrogen arising from the liquid has nearly the density of air—that is, it is fourteen times that of the gas at the ordinary temperature. Reduction of the pressure by an air-pump brings down the temperature to *minus* 258 degrees, when the liquid becomes a solid resembling frozen foam, and this by further exhaustion is cooled to minus 260 degrees, or 13 degrees absolute, which is the lowest steady temperature that has been reached. The solid may also be got in the form of a clear transparent ice, melting at about 15 degrees absolute, under a pressure of 55 mm., possessing the unique density of one eleventh that of water. Such cold involves the solidification of every gaseous substance but one that is at present definitely known to the chemist, and so liquid hydrogen introduces the investigator to a world of solid bodies. The contrast between this refrigerating substance and liquid air is most remarkable. On the removal of the loose plug of cotton-wool used to cover the mouth of the vacuum vessel in which it is stored, the action is followed by a miniature snowstorm of solid air, formed by the freezing of the atmosphere at the point where it comes into contact with the cold vapor rising from the liquid. This solid air falls into the vessel and accumulates as a white snow at the bottom of the liquid hydrogen. When the outside of an ordinary test-tube is cooled by immersion in the liquid, it is soon observed to fill up with solid air, and if the tube be now lifted out a double effect is visible, for liquid air is produced both in the inside and on the outside of the tube—in the one case by the melting

of the solid, and in the other by condensation from the atmosphere. A tuft of cotton-wool soaked in the liquid and then held near the pole of a strong magnet is attracted, and it might be inferred therefrom that liquid hydrogen is a magnetic body. This, however, is not the case: the attraction is due neither to the cotton-wool nor to the hydrogen—which indeed evaporates almost as soon as the tuft is taken out of the liquid—but to the oxygen of the air, which is well known to be a magnetic body, frozen in the wool by the extreme cold.

The strong condensing powers of liquid hydrogen afford a simple means of producing vacua of very high tenuity. When one end of a sealed tube containing ordinary air is placed for a short time in the liquid, the contained air accumulates as a solid at the bottom, while the higher part is almost entirely deprived of particles of gas. So perfect is the vacuum thus formed that the electric discharge can be made to pass only with the greatest difficulty. Another important application of liquid air, liquid hydrogen, etc., is as analytic agents. Thus, if a gaseous mixture be cooled by means of liquid oxygen, only those constituents will be left in the gaseous state which are less condensable than oxygen. Similarly, if this gaseous residue be in its turn cooled in liquid hydrogen a still further separation will be effected, everything that is less volatile than hydrogen being condensed to a liquid or solid. By proceeding in this fashion it has been found possible to isolate helium from a mixture in which it is present to the extent of only one part in one thousand. By the evaporation of solid hydrogen under the air-pump we can reach within 13 or 14 degrees of the zero, but there or thereabouts our progress is barred. This gap of 13 degrees might seem at first sight insignificant in comparison with the hundreds that have already been conquered. But to win one degree low down the scale is quite a different matter from doing so at higher temperatures; in fact, to annihilate these few remaining degrees would be a far greater achievement than any so far accomplished in low-temperature research. For the difficulty is twofold, having to do partly with process and partly with material. The application of the methods used in the liquefaction of gases becomes continually harder and more troublesome as the working temperature is reduced; thus, to pass from liquid air to liquid hydrogen —a difference of 60 degrees—is, from a thermodynamic point of view, as difficult as to bridge the gap of 150 degrees that separates liquid chlorine and liquid air. By the use of a new liquid gas exceeding hydrogen in volatility to the same extent as hydrogen does nitrogen, the investigator might get to within five degrees of the zero; but even a second hypothetical substance, again exceeding the first one in volatility to an equal extent, would not suffice to bring him quite to the point of his ambition. That the zero will ever be reached by man is extremely improbable. A thermometer introduced into regions outside the uttermost confines of the earth's atmosphere might approach the absolute zero, provided that its parts were highly transparent to all kinds of radiation, otherwise it would be affected by the radiation of the sun, and would therefore become heated. But supposing all difficulties to be overcome, and the experimenter to be able to reach within a few degrees of the zero, it is by no means certain that he would find the near approach of the death of matter sometimes pictured. Any forecast of the phenomena that would be seen must be based on the assumption that there is continuity between the processes studied at attainable temperatures and those which take place at still lower ones. Is such an assumption justified? It is true

that many changes in the properties of substances have been found to vary steadily with the degree of cold to which they are exposed. But it would be rash to take for granted that the changes which have been traced in explored regions continue to the same extent and in the same direction in those which are as yet unexplored. Of such a breakdown low-temperature research has already yielded a direct proof at least in one case. A series of experiments with pure metals showed that their electrical resistance gradually decreases as they are cooled to lower and lower temperatures, in such ratio that it appeared probable that at the zero of absolute temperature they would have no resistance at all and would become perfect conductors of electricity. This was the inference that seemed justifiable by observations taken at depths of cold which can be obtained by means of liquid air and less powerful refrigerants. But with the advent of the more powerful refrigerant liquid hydrogen it became necessary to revise that conclusion. A discrepancy was first observed when a platinum resistance thermometer was used to ascertain the temperature of that liquid boiling under atmospheric and reduced pressure. All known liquids, when forced to evaporate quickly by being placed in the exhausted receiver of an air-pump, undergo a reduction in temperature, but when hydrogen was treated in this way it appeared to be an exception. The resistance thermometer showed no such reduction as was expected, and it became a question whether it was the hydrogen or the thermometer that was behaving abnormally. Ultimately, by the adoption of other thermometrical appliances, the temperature of the hydrogen was proved to be lowered by exhaustion as theory indicated. Hence it was the platinum thermometer which had broken down; in other words, the electrical resistance of the metal employed in its construction was not, at temperatures about *minus* 250° C., decreased by cold in the same proportion as at temperatures about *minus* 200°. This being the case, there is no longer any reason to suppose that at the absolute zero platinum would become a perfect conductor of electricity; and in view of the similarity between the behavior of platinum and that of other pure metals in respect of temperature and conductivity, the presumption is that the same is true of them also. At any rate, the knowledge that in the case of at least one property of matter we have succeeded in attaining a depth of cold sufficient to bring about unexpected change in the law expressing the variation of that property with temperature, is sufficient to show the necessity for extreme caution in extending our inferences regarding the properties of matter near the zero of temperature. Lord Kelvin evidently anticipates the possibility of more remarkable electrical properties being met with in the metals near the zero. A theoretical investigation on the relation of 'electrions' and atoms has led him to suggest a hypothetical metal having the following remarkable properties; below one degree absolute it is a perfect insulator of electricity, at two degrees it shows noticeable conductivity, and at six degrees it possesses high conductivity. It may safely be predicted that liquid hydrogen will be the means by which many obscure problems of physics and chemistry will ultimately be solved, so that the liquefaction of the last of the old permanent gases is as pregnant now with future consequences of great scientific moment as was the liquefaction of chlorine in the early years of the last century.

The next step towards the absolute zero is to find another gas more volatile than hydrogen, and that we possess in the gas occurring in clevite, identified by Ramsay as helium, a gas which is widely distrib-

uted, like hydrogen, in the sun, stars, and nebulæ. A specimen of this gas was subjected by Olszewski to liquid air temperatures, combined with compression and subsequent expansion, following the Cailletet method, and resulted in his being unable to discover any appearance of liquefaction, even in the form of mist. His experiments led him to infer that the boiling-point of the substance is probably below nine degrees absolute. After Lord Rayleigh had found a new source of helium in the gases which are derived from the Bath springs, and liquid hydrogen became available as a cooling agent, a specimen of helium cooled in liquid hydrogen showed the formation of fluid, but this turned out to be owing to the presence of an unknown admixture of other gases. As a matter of fact, a year before the date of this experiment I had recorded indications of the presence of unknown gases in the spectrum of helium derived from this source. When subsequently such condensable constituents were removed, the purified helium showed no signs of liquefaction, even when compressed to eighty atmospheres, while the tube containing it was surrounded with solid hydrogen. Further, on suddenly expanding, no instantaneous mist appeared. Thus helium was definitely proved to be a much more volatile substance than hydrogen in either the liquid or solid condition. The inference to be drawn from the adiabatic expansion effected under the circumstances is that helium must have touched a temperature of from nine to ten degrees for a short time without showing any signs of liquefaction, and consequently that the critical point must be still lower. This would force us to anticipate that the boiling-point of the liquid will be about five degrees absolute, or liquid helium will be four times more volatile than liquid hydrogen, just as liquid hydrogen is four times more volatile than liquid air. Although the liquefaction of the gas is a problem for the future, this does not prevent us from safely anticipating some of the properties of the fluid body. It would be twice as dense as liquid hydrogen, with a critical pressure of only four or five atmospheres. The liquid would possess a very feeble surface-tension, and its compressibility and expansibility would be about four times that of liquid hydrogen, while the heat required to vaporize the molecule would be about one fourth that of liquid hydrogen. Heating the liquid one degree above its boiling-point would raise the pressure by one and three fourth atmospheres, which is more than four times the increment for liquid hydrogen. The liquid would be only seventeen times denser than its vapor, whereas liquid hydrogen is sixty-five times denser than the gas it gives off. Only some three or four degrees would separate the critical temperature from the boiling-point and the melting-point, whereas in liquid hydrogen the separation is respectively ten and fifteen degrees. As the liquid refractivities for oxygen, nitrogen, and hydrogen are closely proportional to the gaseous values, and as Lord Rayleigh has shown that helium has only one fourth the refractivity of hydrogen, although it is twice as dense, we must infer that the refractivity of liquid helium would also be about one fourth that of liquid hydrogen. Now hydrogen has the smallest refractivity of any known liquid, and yet liquid helium will have only about one fourth of this value—comparable, in fact, with liquid hydrogen just below its critical point. This means that the liquid will be quite exceptional in its optical properties, and very difficult to see. This may be the explanation of why no mist has been seen on its adiabatic expansion from the lowest temperatures. Taking all these remarkable properties of the liquid into consideration, one is afraid to predict that we are at

present able to cope with the difficulties involved in its production and collection. Provided the critical point is, however, not below eight degrees absolute, then from the knowledge of the conditions that are successful in producing a change of state in hydrogen through the use of liquid air, we may safely predict that helium can be liquefied by following similar methods. If, however, the critical point is as low as six degrees absolute, then it would be almost hopeless to anticipate success by adopting the process that works so well with hydrogen. The present anticipation is that the gas will succumb after being subjected to this process, only, instead of liquid air under exhaustion being used as the primary cooling agent, liquid hydrogen evaporating under similar circumstances must be employed. In this case the resulting liquid would require to be collected in a vacuum vessel, the outer walls of which are immersed in liquid hydrogen. The practical difficulties and the cost of the operation will be very great; but on the other hand, the descent to a temperature within five degrees of the zero would open out new vistas of scientific inquiry, which would add immensely to our knowledge of the properties of matter. To command in our laboratories a temperature which would be equivalent to that which a comet might reach at an infinite distance from the sun would indeed be a great triumph for science. If the present Royal Institution attack on helium should fail, then we must ultimately succeed by adopting a process based on the mechanical production of cold through the performance of external work. When a turbine can be worked by compressed helium, the whole of the mechanism and circuits being kept surrounded by liquid hydrogen, then we need hardly doubt that the liquefaction will be effected. In all probability gases other than helium will be discovered of greater volatility than hydrogen. It was at the British Association Meeting in 1896 that I made the first suggestion of the probable existence of an unknown element which would be found to fill up the gap between argon and helium, and this anticipation was soon taken up by others and ultimately confirmed. Later, in the Bakerian Lecture for 1901, I was led to infer that another member of the helium group might exist having the atomic weight about 2, and this would give us a gas still more volatile, with which the absolute zero might be still more nearly approached. It is to be hoped that some such element or elements may yet be isolated and identified as coronium or nebulium. If amongst the unknown gases possessing a very low critical point some have a high critical pressure, instead of a low one, which ordinary experience would lead us to anticipate, then such difficultly liquefiable gases would produce fluids having different physical properties from any of those with which we are acquainted. Again, gases may exist having smaller atomic weights and densities than hydrogen, yet all such gases must, according to our present views of the gaseous state, be capable of liquefaction before the zero of temperature is reached. The chemists of the future will find ample scope for investigation within the apparently limited range of temperature which separates solid hydrogen from the zero. Indeed, great as is the sentimental interest attached to the liquefaction of these refractory gases, the importance of the achievement lies rather in the fact that it opens out new fields of research and enormously widens the horizon of physical science, enabling the natural philosopher to study the properties and behavior of matter under entirely novel conditions. This department of inquiry is as yet only in its infancy, but speedy and extensive developments may be looked for, since within recent years sev-

eral special cryogenic laboratories have been established for the prosecution of such researches, and a liquid-air plant is becoming a common adjunct to the equipment of the ordinary laboratory.

JAMES DEWAR.

(To be concluded.)

THE BUREAU OF GOVERNMENT LABORATORIES FOR THE PHILIPPINE ISLANDS, AND SCIENTIFIC POSITIONS UNDER IT.

THE Bureau of Government Laboratories for the Philippine Islands has now been organized for nine months and is at present quartered in a temporary building. The commission contemplates the erection of a comprehensive and fitting structure for scientific work, the detailed plans of which are about completed, and the government architect is ready to begin work as soon as the title to the land desired for the edifice is secured. This new structure will be fitted with all modern appliances for thorough scientific work. The individual working desks of the laboratory will be supplied with gas, water, vacuum and steam and air pressure; electric power is to be furnished wherever it is needed, and the equipment will be complete.

The scheme of the bureau contemplates a central institution in which laboratory work shall be done for all the bureaus which may need scientific assistance, so that a scattering of individual laboratories and a consequent loss of efficiency and equipment are avoided. The work is separated into two divisions, the chemical laboratory and the biological laboratory, each occupying a wing of the new building, with the Serum Institute located to the rear, in conjunction with the power house.

The building is divided into sixty rooms so that separate lines of work can be carried on in individual quarters, each person engaged in scientific investigation being thus enabled to have his apparatus and appliances in the most convenient form. The division of the space is as follows:

GROUND FLOOR.

Physical laboratory with constant temperature room below.
Assay laboratory.
Balance room.
Combustion room.
Distilling room.
Research room for vegetable products.
Chemical stores.
Apparatus stores.
Storekeeper's office.
Bacteriological diagnosis, two rooms.
Animal parasites.
Culture media.
Mechanic.
Incubator and cold storage.

FIRST FLOOR.

Mineral analysis.
Director chemical laboratory.
Director's office.
Sugar and food analysis.
Library.
Plant pathology.
Biological director's office.
Biological director's laboratory.
Biological research.
Spectroscopic rooms.
Chemical research.
Pharmacology.
Balance room.
Photography.
Collections.
Pathology.
Physiological chemist.
Three research rooms.
Outdoor laboratory.

POWER HOUSE.

Cold-storage plant and cold-storage rooms.
Serum packing room.
Serum laboratory.
Serum kitchen.
Crematory.
Engine room.
Boiler room.

The plans of the bureau contemplate research work not only in the resources of the islands, but also in the realm of tropical diseases. The work during the past year has included a large number of analyses for

the Custom House, Mining Bureau, Forestry Bureau, Agricultural Department and Board of Health; diagnostic work for the hospitals and others interested, and researches in gutta-percha, rubber and gums found in the islands, as well as investigations of some previously unknown forms of tropical diseases. The scope of the work is continually widening, and there is no doubt but that the bureau offers large opportunities for young men who desire to acquaint themselves with the products of the tropics and to advance our knowledge of lines of work which are each year concentrating more and more of the interest of the scientific world.

The positions in the bureau, outside of the directors, are all under the Civil Service, and qualifications can be obtained through the Civil Service Commission at Washington. The scheme of the bureau contemplates the following additions to the laboratory force during the next year:

1 Soil and water analyst	$1,500
1 Plant pathologist	2,500
1 Physical chemist	2,400
1 Analytical chemist for mineral analysis	2,000
1 Assayer	1,500
1 Entomologist	2,500
1 Animal parasitologist	2,500
1 Pathologist	2,400
1 Drug assayer and toxicologist	1,800

The candidates for the higher salaried positions by understanding will not be subjected to a rigid examination, but their previous research work, experience, university degrees and general knowledge will qualify them, after the facts have been submitted to the Civil Service Board and found satisfactory.

The salaries for young men are good, and, although expenses in Manila are higher than in the United States, nevertheless, the difference in salaries is large enough so that prospective workers will be better paid here than they would in the beginning positions in the United States. It is the intention to engage none but the most efficient workers in the corps, and it is hoped, in the course of a few years, a connection with the Bureau of Government Laboratories will be equivalent to a certificate of the superior attainments.

The plan of the institution contemplates the reservation of a certain number of research rooms in the laboratory building. These are to be at the disposition of independent investigators who wish to come to the islands for a temporary period as the guests of the laboratories. These workers will be furnished all the laboratory facilities they desire, and it is hoped that the opportunities offered will render scientific study in the tropics easy of access to all who have planned to undertake certain lines of work in which they are interested.

Paul C. Freer,
Superintendent of Government Laboratories.

THE CARNEGIE INSTITUTION.

Aid to research may be given either to individuals or to groups or organizations of individuals.

One of the chief obstacles in this country at present to research by individuals is the lack of time for continuous, well-adjusted work. The majority of the persons engaged in active scientific investigation in the United States are connected with colleges or universities, and in nearly every instance definite accomplishment is expected from them in the way of instruction and administration. The exigencies—real or fancied—of university administration often lead to wasteful repetition of courses and to the exhaustion of energy in barren details of executive routine and elementary instruction. The most common complaint heard from American men of science is not regarding inadequate salaries, but regarding the scanty time afforded them for the work of investigation. While in some cases this

attitude may be temperamental and not to be remedied by the acquisition of greater leisure, in a great many instances it represents the real barrier to be removed. More ample time for research can be afforded highly qualified individual workers by provision for research assistants, provision for the purchase or manufacture of special or expensive apparatus, or possibly by arrangement with university authorities for relief from an undue burden of elementary instruction.

In addition to the assistance that may be afforded individual workers of maturity and position, there is a scarcely less important field open in the granting of assistance to those just entering upon a professional career. It is no longer true that the attainment of the degree of doctor of philosophy carries with it the immediate offer of a college chair or indeed of any position whatever. The period intervening between the obtaining of the doctorate and the securing of a satisfactory academic position is often the most critical in the whole career of the young investigator. American conditions have not favored the engrafting of the docent system, and as matters stand at present there is nothing to bridge over this difficult transition period. Men with promise of high capability for investigation are often forced at this stage into the premature preparation of text-books or into other still less permanently valuable activities. It is of course not true that all young men receiving the degree of doctor of philosophy are equally worthy of assistance, but there are always some among each year's graduates who should not be smothered with routine or with bread-and-butter work before they have been allowed to develop their powers to the fullest extent. The whole future of research depends upon these beginning investigators, and the best of them should be carefully sought for, and when found given every opportunity to make the most of themselves.

Organized groups or associations of scientific men may further the interests of research in a somewhat different way. Undertakings impossible for the individual workers may be set on foot and carried through to a triumphant conclusion by the cooperation of many workers in different localities; extended series of experiments may be carefully planned and coordinated, and a system for the rapid interchange of results and methods may be made to accelerate greatly the work in hand without in any way curtailing the independence or freedom of the individual worker. There are already instances—as in the study of the physiological action of alcohol—where such cooperative, coordinated methods have been effectively applied. This tendency is apparent in many directions. Special institutes for the study of cancer and of scarlet fever, special committees for the study of biological variation, of atomic weight, of water analysis and of many other topics appealing to considerable groups of workers are utilizing the services of many individuals and are greatly facilitating concentration along effective lines. The impulse towards economy of energy that has led to industrial concentration is forcing upon scientific work the same necessity. Isolated, desultory work is becoming distinctly less effective; researches by groups of investigators, whether of master and pupils or of larger groups, are playing an increasing part in the advancement of science. Some branches of scientific work are especially fortunate in possessing already well-organized associations for the advancement of research. The eminent group of naturalists who have founded and maintained the Marine Biological Laboratory is one of the most notable of these associations. It would seem most natural that the Carnegie Institu-

tion should first of all take advantage of the existing organizations for research without destroying their independence, and it would also follow that it might properly aid in the opening up of fields of work hitherto not so well supplied with opportunities for investigation. National societies representing well-defined territories of scientific endeavor might well be asked to appoint a 'Committee on Research' whose function it should be to represent the society in conference with the authorities of the Carnegie Institution, and perhaps to suggest not merely the nature of assistance it is desirable to render to the individual investigators that it represents, but to formulate plans for a comprehensive and protracted study of definite fundamental problems.

It would seem as if existing agencies for promoting research should be fully utilized before any attempt is made to create another organization. These agencies may be found in and directed through the several national societies whose avowed aim is the promotion of research. Practically all the workers in the different natural sciences are organized in some way, and while the details of the organization are quite different, the controlling purpose is the same. In some sciences the number of societies is excessive and illustrates the national tendency toward multiplication of executive mechanism, but, as is well known, various plans for unification and centralization are even now being considered. By inviting the cooperation and advice of these societies of national scope and by stimulating their activities the solidarity of scientific organization will be increased and enthusiasm for research greatly stimulated. More would probably be accomplished in this way than by adding another set of wheels to the existing machinery for transacting scientific business.

Edwin O. Jordan.

In complying with the request of the editor of Science for an expression of opinion regarding the work of the Carnegie Institution, I must speak solely from the standpoint of my own specialty, though possibly the suggestions are capable of a wider application.

First of all, it is important that the funds of this great donation should be utilized for the furtherance of work which cannot be accomplished in any other way. Secondly, it is understood that these funds are to be used primarily for the furtherance of research.

What is the greatest hindrance to chemical research in this country? There go out from our different universities each year men well equipped for research, and this number is increased by others returning from German and other foreign universities. After perhaps the publication of a résumé of their theses, little is heard from most of these men, yet many of them have begun the study of interesting problems. The reason for this is not far to seek. Those who have entered upon a career of teaching have found themselves so burdened with class-room work that they have neither time nor energy for continuing their researches. In many positions research work means to the trustees that the teacher is not devoting the time he should to his classes. In a comparatively few institutions there are positions as assistant, where a man has time for research and is possibly expected to engage in it, but such positions are generally temporary, and the incumbent, if successful, is soon promoted to a place where he receives adequate salary and spends most, if not all, his time in teaching. Every chemist will recall numerous examples of men who have given great promise, but have soon had a quietus put upon their research work. There are comparatively few teachers in this country so situated that

they can carry on such work, and still fewer who are in a position to direct such work, for it must be borne in mind that if one man has to carry out all the manipulation of a line of research, it will of necessity be rather limited in its scope.

These conditions it is practically impossible for most of the universities of the country to improve, limited as they are in their funds. Would it not accomplish the aims of the donor if a portion of the income of the Carnegie funds were used as fellowships, which would enable men who had already given good promise to go on with their work at some university of their choice, the income from the fellowships being large enough to support them adequately, and being renewable for several years if deemed wise in individual instances? In some cases it might be well to award these fellowships to older men, that they might be enabled to employ assistants to carry out lines of research, which it would be an impossibility for them to accomplish alone on account of their pedagogical duties. Many a teacher of chemistry could bring forth valuable results if he had an assistant to carry on manipulations, for which he himself cannot find the time. As far as I know, none of the research funds now available could be legitimately used for the purpose of employing assistants.

There is another direction in which the Carnegie committee on research in chemistry, should such be appointed, could render valuable aid to the cause of chemical research, and that without the expenditure of any considerable sum beyond their own salaries. This is in pointing out desirable directions of research. Many young men, just starting on their careers as teachers, are anxious to take up some line of investigation but do not know just what to select. On the other hand, there are many lines upon which it is desirable that work should be done, with no one to undertake it. Such a committee could render invaluable service by acting as a sort of *chemical research clearing-house*. The whole field of inorganic chemistry, for example, is full of gaps which need to be filled out, as well as of old material which needs to be reexamined. Professor F. W. Clarke has elsewhere called attention to the assistance which could be rendered by a suitable committee in this direction. It would doubtless secure the immediate cooperation of scores of young chemists, and the possibilities in this direction are almost limitless. I am well aware of the fact that there must be a spontaneity about research, but nine young men out of ten will be wisely guided by older heads when setting out upon a career of investigation.

There is one other direction in which a portion of the Carnegie funds might be turned, with the assurance of accomplishing much for chemical research. This is the establishment of an American counterpart of the Davy-Faraday Research Laboratory of the Royal Institution, and its adequate endowment. This would, however, probably require more than the proportion of the funds that should justly be allotted to chemistry, unless the province of the Institution should be confined to a few sciences only; but its value would be unquestionable.

J. L. HOWE.

IN my opinion the final policy of the Carnegie Institution can only develop with time, and at the outset a tentative plan should be adopted which would not involve the investment of a considerable sum in a working plant of any kind, and especially in duplicating plants already in existence. I would, therefore, suggest that for the present the income be devoted mainly to subsidizing such researches and such investigators as seem to be worthy, utilizing

existing laboratories and cooperating with existing institutions for the purpose. It would then be possible to modify the plan at any time without loss, if the erection of special buildings or laboratories should appear desirable.

From the statistics of doctorates conferred during the past five years (SCIENCE, Sept. 5, 1902, p. 363) it appears that twice as many degrees were given in chemistry (137) as in any other subject, physics following with 68. We certainly have now enough chemical and physical laboratories to meet present requirements, and money expended in these sciences should be devoted, not to equipping new ones, but rather in assisting existing ones to do better work, by aiding the purchase of apparatus and supplies (including books) with a view to special work, and in encouraging the most promising men to continue their investigations. Most of the new doctors will never again appear as producers of works of pure science, not always because of disinclination or incapacity, but because of the necessity of earning a living by devoting themselves to more profitable pursuits. Probably few scientific men work with the view of disinterestedly promoting science. More powerful motives are the desire of approbation and of wealth. The best men are quite as desirous as others of attaining social standing, and, as every one knows, social standing in this country depends not so much on what one does or attains, as on what one spends, and few men are so constituted that the pleasures of scientific discovery or the approbation of perhaps a dozen specialists is sufficient compensation for poverty and social neglect, and this feeling is likely to increase rather than diminish with advancing age.

The Carnegie Institution should, therefore, do as much as possible to render life socially endurable to the best investigators by offering liberal assistance, in the form either of salaries or of subsidies for investigation, with the understanding that they are to accept no expert work requiring much time, and conduct no researches the results of which are not to become public property, and then only when it is clear that they would otherwise be driven to other occupations. The awarding substantial prizes for good work would afford a further means of encouraging research, care being taken that it does not lead to duplication, as may happen when special problems are proposed for solution. Of course all immediately practical problems for the solution of which there exists a sufficient financial inducement should be avoided.

With regard to publication, my opinion is that no encouragement whatever should be given to such composite publications as the Proceedings of Academies, or those college or university journals of mixed character, the object of which is clearly to advertise the institutions at the expense of a wide circulation of the results among specialists concerned. These have their own reward. The publication of monographs might well be undertaken, and assistance given to special journals in the case of meritorious papers which would clearly otherwise go unpublished. The establishment of a printing and engraving plant, however, would seem inadvisable at present, for reasons given above.

The organization and direction of research, while offering a field of usefulness, might easily be carried too far. The best scientific minds are intensely individualistic, and the attempt to place a really original investigator under the direction of another man would only result in detriment to his work. Unless, therefore, it should clearly appear in any case that direction is indispensable the institution should limit itself to bringing investigators

together for the purpose of deciding the nature of the most important problems to be attacked, and the best men to undertake the work, but beyond affording the means it should leave them with as little supervision as possible, judging them by the results.

In conclusion, I heartily concur with other writers as to the desirability of especially encouraging work in the hygienic sciences, psychology, physical and chemical geology and other subjects which have as yet obtained but little foothold in our educational institutions.

H. N. STOKES.

U. S. GEOLOGICAL SURVEY.

I THINK that Professor Cattell has done a public service in setting forth at length his views of the best ways to employ Mr. Carnegie's gift. I thoroughly agree with the two general principles he lays down: (1) That the institution must work in harmony with existing establishments, and (2) that it should aim to improve the condition of men of science, working with them and through them. We want no popes in science, nor any councils of ten with supreme power. The past history of some of our scientific societies and the present pretensions of some of our too-numerous scientific congresses show what is to be avoided. First of all let the man of science be free. Then assist him if you can. To the paragraph beginning 'I should like to see at Washington a Carnegie Institution somewhat on the plan of the Royal Institution of London' I give assent qualified by the remark that the Smithsonian Institution should do the work proposed, and gain the time for it by giving up its grip on the National Museum, the Zoological Park, and the Bureau of Ethnology. Its proper business is to assist those institutions when it can, not to petrify them into units of a rigid administrative machine. The Carnegie funds would provide the necessary income, building, etc.; the slight administrative machinery needed should be the work of the Smithsonian Institution clerks. The secretary of the institution should be, ex officio, a member of the board of managers with a voice and one vote. The salary of the members need not be above $1,000 per year—just enough to pay their travelling expenses, hotel bills, and a reasonable fee for their lectures, etc.

The suggestion as to the establishment of an endowed scientific press seems to be admirably adapted to cure abuses which have long existed and especially to stimulate the prompt publication of first-class work. Provision should be made to assist the printing of original work, as is now done by the Oxford authorities, etc.

A small addition to the income of an establishment will often produce results that are out of all proportion to the amount. For instance, the gift of even $1,000 a year to the Lick Observatory funds in 1886–97 would have made many rough places smooth. A single computer added to the staff would have relieved our best men from much drudgery and left them free to do the work for which they were fitted. Subsidies should be given to astronomical observatories already established; and they should be given only for a limited term of years—during good behaviour. If after a reasonable time the subsidies produced little or nothing they should be discontinued. The very best way to assist research in astronomy is to pay salaries to young astronomers. An effective form of assistance is to establish fellowships with incomes of $1,000 or less.

Small grants in aid of the publications of worthy scientific societies or journals would have an immediate and far-reaching effect.

If a plan can be devised to utilize men of talent or genius, 'who for some reason or

other have not found a place in our social machinery' great things might follow. We all know such men. What might not come from some of them if their lives were made a little easier?

Perhaps the foregoing sentences may serve a useful purpose in emphasizing Professor Cattell's proposals. If the two general principles he lays down are frankly adopted and adhered to, most of the rest of the business will be a matter of detail.

Edward S. Holden.

U. S. Military Academy,
West Point, Sept. 15, 1902.

Editor of Science: I have read your suggestions on the Carnegie Institution with much interest, but my thought does not run in the same line with your own. All that you say is true about the lack of support to the development of abstract science, but in one way or another the man who possesses the capacity to develop science along the lines of the highest investigation finds the way to do it. True, it may be like many inventors, he cannot stop if he tries to. In the end he works out the results.

However or by whom begun in very many branches of applied science and invention, the work gets done, either in spite of or by means of patent laws, which I am inclined to think rather retard than promote invention. The practical application of scientific methods to arts that pay large profits works out in some way; often the inventor gets little or nothing, the promoters get all, but the community has the benefit of the invention.

According to my observation, there is a middle term in which there is an enormous gap which neither inventor, promoter nor the masters of higher branches of science have attempted to fill. A great amount of mental energy has been given to the development of the steam-engine, and yet the steam-engine is the most wasteful machine now in existence; until lately we have been far behind in the gas-engine. Invention has been given to cooking apparatus, yet the waste of food and fuel is the biggest waste of the whole country. Invention has been applied to providing all the apparatus for extinguishing fire, and yet the fire waste of this country is a disgrace to the nation.

I attribute this fire waste in large measure to ignorance, stupidity and criminal negligence on the part of the owners, builders and architects of existing buildings. I have chosen that line in extending the application of science to the Prevention of Loss by Fire, as will duly appear in the documents which I send you under separate cover. But there is another line hardly yet touched, to which, in my judgment, the attention of the trustees of the Carnegie fund might well be called.

Invention has been applied to the fullest extent to the development of agricultural implements and to the working of the soil; but is not the art of using the soil itself as a mere instrument of production rather than as a mine subject to exhaustion, yet in its infancy? We have but lately learned, almost by accident, the power of certain plants to draw nitrogen from the atmosphere. We know as yet but little about hybridizing food plants, although we know a great deal about the development of fancy flowers by that method. We know in this country but little about the cross-breeding of sheep. The waste of skimmed milk is something enormous, and the excellent food property of cooked skim cheese common in Italy is almost unknown to us.

The beginnings have been made in a quiet way; the agricultural experiment stations of the country have grown up almost unbeknown to the mass of the people. They occupy an anomalous condition, partly supported by the National

Government, partly by the States, often by auxiliaries, colleges or universities. I think there is no body of men performing so great service as the experts connected with many of these agricultural experiment stations. I have had occasion to correspond with them in dealing with the wheat supply and the cotton supply of the country, and in making an effort to get the people of the Piedmont plateau and of the Atlantic Cotton States to renovate their soil by pasturing sheep upon the cotton field, admitted to be feasible, were it not for the cur-dog; where there is not sufficient intelligence to muzzle the cur-dog it is hopeless to expect any intelligent method of agriculture of any kind that can be widely extended. In my judgment one of the greatest services that managers of the Carnegie fund could work at would be aiding those agricultural stations in which the best work has been done. There are two by which the whole standard of dairy products of their respective states has been raised to a very high point; one or two in which varieties of Indian corn have been generated containing as much or a larger element of protein than is found in the average of wheat.

Another, where the production of sugar has been dealt with, whether any efforts have been made to hybridize sugar-cane and maize, I know not. A very moderate aid, especially in the matter of laboratory and libraries, might be of immense service in guiding the revolution in agriculture of this country which is now going on; mainly from extensive ignorant dealing with the soil as a mine subject to exhaustion, to an intelligent and intensive method of using the soil as an instrument of production, responding in its abundant yield in just proportion to the measure of mental energy and practical skill that may be applied to it.

If you think this missive will be of any service, you are at liberty to print it.

EDWARD ATKINSON.

EDITOR OF SCIENCE: Your letter of September 8 asking an expression of opinion as to the most effective way in which the Carnegie Institution can contribute to the advancement of science, has just reached me in the North Woods, where I am spending my vacation.

The question which you suggest, and which is now before the trustees of the Institution, appeals strongly to all men who have at heart the advancement of science, and I suppose that all such have given the subject some thought. So far as I have been able to consider it, my thinking has led toward the following conclusions.

I understand the purpose of the Carnegie Institution to be the promotion of scientific research. At the present moment three directions seem to me open to the Institution, along which it may proceed to carry out its purpose:

1. By establishing and maintaining, under the direction of the trustees, an institution devoted to research.

2. By assisting men in universities, colleges and other existing institutions to carry to conclusion researches already begun or planned.

3. By seeking out men of extraordinary ability, outside of regular institutions, and putting them in the way to conduct researches or to perfect discoveries.

Of these three methods of procedure the first is the direct one. My own experience in the scientific work of the Government and of private institutions of learning long ago led me to think that an institution in Washington, modeled somewhat after the Royal Institution, and independent of government support, would have a great opportunity for usefulness. Should the Carnegie Institution provide such an es-

tablishment, and bring to it a limited number of the ablest investigators and student assistants, it would thereby give, in my judgment, the most direct and powerful stimulus to research which could be rendered.

The promotion of research by assisting investigators in existing institutions constitutes a means which will doubtless receive the most careful consideration at the hands of those who direct the Carnegie Institution. Undoubtedly great possibilities for stimulating research are to be found in our universities and colleges. Nevertheless the wise use of funds in this way is beset with many difficulties. In most American institutions of learning the conditions which obtain are not favorable to the development of the research spirit, and it would be entirely possible to expend the entire income of the Carnegie Institution in this way and obtain no other results than those of a mediocre and routine nature. In no other direction will the managers of the Institution be called upon for a greater measure of that good judgment which couples keen discrimination with sympathetic appreciation, than in their endeavor to assist research in existing institutions.

The third line of activity to which I have alluded has its peculiar difficulties also, though of a different sort from those just referred to.

An institution founded for the promotion of research will not be content to get in touch only with those already fairly known and started in the work of investigation. It will seek to introduce the new sciences as well as to stimulate the old to new triumphs. It will desire to discover the discoverer, to keep a door always accessible to the unknown and obscure investigator. By such a door an army of cranks will seek to enter, but so also will the unheralded genius. Now and then a Thomson, an Edison or a Marconi will knock for admission; mayhap a Henry or a Pasteur. It is here—in the endeavor to come in touch with the unknown struggling man of genius—that those who direct the Institution will find at the same time their keenest disappointments and their greatest successes; and here again is a wise sympathy no less needed than a keen scrutiny.

Of the three plans of procedure here suggested the first is, to my thinking, the prop and the inspiration of the other two.

If the Carnegie Institution succeeds not only in bringing to accomplishment certain useful researches, but also in awakening the spirit of research itself, its success will have momentous consequences for the whole world. No other project has at this moment so fully the attention of all men of science. In their effort to execute the delicate and important task committed to them the directors of the Institution are sure to receive the cordial cooperation, as they already have the keen attention, of those who are interested in science and in the progress of men.

HENRY S. PRITCHETT.

MEMBERSHIP OF THE AMERICAN ASSOCIATION.

THE following is a list of persons who have completed membership in the Association during August, 1902.

Thos. L. Armitage, M.D., Physician and Surgeon, Princeton, Minn.

Oscar P. Austin, Chief of Bureau of Statistics, Treasury Department, Washington, D. C.

Theodore Baker, Box 44, Haskell, N. J.

Howard J. Banker, Professor of Biology, Southwestern Normal School, California, Pa.

John Barlow, State College, Kingston, R. I.

John E. Best, M.D., Physician, Arlington Heights, Ill.

Mrs. Josephine Hall Bishop, 2309 Washington St., San Francisco, Cal.

James Hall Bishop, 2309 Washington St., San Francisco, Cal.

Anson W. Burchard, 44 Broad St., New York City.

Flemming Carrow, M.D., University of Michigan, Ann Arbor, Mich.

Ira J. Dunn, M.D., Physician, 810 Peach St., Erie, Pa.

Ernst Fahrig, Chief of Laboratories, Philadelphia Commercial Museums, Philadelphia, Pa.

Geo. H. Gibson, 268 Shady Ave., E. E., Pittsburgh, Pa.

Ozni P. Hood, Professor of Mechanical and Electrical Engineering, School of Mines, Houghton, Mich.

G. Wilbur Hubley, Electric Light Co., Louisville, Ky.

Herman C. Jungblut, M.D., Physician, Tripoli, Iowa.

Orran W. Kennedy, General Superintendent, Frick Coke Co., Uniontown, Pa.

Palmer J. Kress, M.D., Physician, 636 Hamilton St., Allentown, Pa.

Benjamin Lee, M.D., Secretary State Board of Health, 1420 Chestnut St., Philadelphia, Pa.

Daniel Lichty, M.D., Physician, Masonic Temple, Rockford, Ill.

Ernest H. Lindley, Professor of Psychology, University of Indiana, Bloomington, Ind.

Robert E. Lyons, Professor of Chemistry, University of Indiana, Bloomington, Ind.

George C. Martin, Assistant Geologist, Maryland Geological Survey, Johns Hopkins University, Baltimore, Md.

Henry F. Naphen, Member of Congress, 311 Pemberton Building, Boston, Mass.

Wm. R. Roney, Mechanical Engineer, 10 Bridge St., New York City.

Saml. P. Sadtler, Consulting Chemist, N. E. corner Tenth and Chestnut Sts., Philadelphia, Pa.

George S. Seymour, 11 Broadway, New York City.

Lee H. Smith, M.D., Physician, Mus. Soc. Nat. Sciences, Buffalo, N. Y.

Fred D. Snyder, M.D., Physican, 10 Center St., Ashtabula, Ohio.

Robert W. Stewart, M.D., Physician, The Ortiz, Cincinnati, Ohio.

Lucius S. Storrs, Geologist, N. P. Ry. Co., St. Paul, Minn.

Henry L. Ward, Secretary Board Trustees, Public Museum, Milwaukee, Wis.

Homer D. Williamson, 133 W. 10th Ave., Columbus, Ohio.

Chas. E. A. Winslow, Instructor of Biology, Mass. Inst. Tech., Boston, Mass.

Walter Wyman, M.D., Surgeon-General, Public Health and Marine Hospital Service, Washington, D. C.

SCIENTIFIC BOOKS.

The Elements of Physical Chemistry. By HARRY C. JONES. New York, The Macmillan Company, 1902. 14 x 21. Pp. x + 565. Bound, $4.

In this, the most pretentious book on physical chemistry which has appeared in English, the author has not departed from the orthodox German school in arrangement of the subject matter; in the treatment, however, many passages show a style which is peculiarly his own. A brief review will show what he believes should be taught in a university course in physical chemistry.

The reader is introduced to the atom and the molecule—the fundamental ideas of the chemist; the laws of combination, determination of atomic weights and then the periodic law are given in detail. In separate chapters are then discussed the various laws, theories and disconnected facts bearing on the physical properties of pure gases, liquids and solids. There is here given much of the work which, prior to 1885, had engaged the attention of chemical philosophers—the discovery of relations between physical properties and constitution. These chapters will afford interesting reading to many who wonder why the chemist requires all the physics he can obtain. There is little in these chapters, however, illustrative of the use of these properties in analysis.

In the fifth section the subject of solutions is considered. This chapter deals with the classical work of Pfeffer on osmotic pressure, of van't Hoff on the analogy between osmotic and gas pressures, of Raoult on the vapor pressures, the origin of the theory of electrolytic dissociation and the arguments in its favor, and a discussion of properties of dilute solutions.

The thirty pages which are devoted to thermochemistry indicate the development of the subject and give methods and results. Electrochemistry requires and merits four times this space for its treatment, since the remarkable

development which modern physical chemistry has experienced in the past fifteen years has been in very large measure due to advances made in electrochemistry. The explanation of the many conflicting results, such as the conductivities of solutions, electromotive force of primary cells, etc., which the modern theory attempts, makes the section very interesting and instructive—almost comparable to the small text-book of LeBlanc.

The chapter on photochemistry deals with actinometry and gives the results of photochemical measurements and an interesting section on the action of the newly discovered radium and polonium. The next chapter, on chemical dynamics and equilibrium, has among its topics the law of mass action and the phase rule of Gibbs, both of which are of modern development. The idea of chemical affinity and activity as affected by modern theories forms the theme of the final pages.

The author is an ardent supporter of the theory of electrolytic dissociation. He states (p. 299): 'We shall see that this theory is fundamental if we hope to raise chemistry from empiricism to the rank of an exact science.' Such is the unfortunate idea which pervades the work. This theory explains more or less satisfactorily various phenomena connected with dilute solutions, mainly aqueous; but it is extremely unfortunate that the concentrated solutions of our daily experience are ignored. So long as authors of texts on physical chemistry take the position that the part is greater than the whole, so long will critical observers be justified in declaring that the subject may be of theoretical importance only.

The method of presentation calls frequently for forward references which will embarrass the student. The theory of electrolytic dissociation is given before the chapter on electrochemistry, the law of mass action is used before it is presented, critical phenomena discussed apart from the phase rule relation for one-component systems, distillation before two-component, etc. This leads to duplication, examples of which are to be found in paragraphs on the thermochemical and volume-chemical methods.

The discussion of the physical properties of bodies even when presented historically should not be restricted to relations connected with constitution. An extension of this chapter to include more of the properties of gases, such as refractive index, viscosity, thermal and electrical conductivity, etc., would be welcomed. A few paragraphs indicating modern work on solid solutions, isohydric solutions, fused salts, decomposition voltages, alloys, velocities of phase formation, false equilibria, crystallization, etc., would have added materially to the interest and value of the book.

A few of the errors must be noted. Ethyl alcohol and water are not separable by fractional distillation (p. 175). All calcium salts are not more soluble in cold than in hot water (p. 179). The freezing-point of a solvent is not always lowered on the addition of another substance (p. 203). The following statements are open to objection or proof: 'A eutectic is the lowest freezing-mixture of two metals: a cryohydrate is the lowest freezing-mixture of two substances' (p. 222); 'the best conductors of heat energy, however, as compared with the worst hardly exceed the ratio of 100 to 1' (p. 320); 'the potential of the normal electrode is 0.56 volt,' and 'a solution has a smaller vapor pressure than the pure solvent' (p. 499). There is no excuse for having given the Ostwald-Nernst proof of free ions (p. 367) nor for assuming that sodium chloride and potassium nitrate cannot exist together (pp. 506–508).

In some places loose definitions or descriptions are given, *e. g.*, the volume of one gram of hydrogen (p. 326), the silver voltameter (p. 325), unit of resistance (p. 337), concentration of zinc chloride (p. 329), etc.

The apparatus and methods employed in the laboratory are frequently described. Translations of pertinent sections from classical papers are inserted and reference made to some of the prominent contributors to the science, the name of Jones not being forgotten.

'The book will find its public.' In the hands of a discriminating and very careful teacher it may be of considerable value.

H. R. Carveth.

DISCUSSION AND CORRESPONDENCE.

THE MARINE BIOLOGICAL LABORATORY AND THE CARNEGIE INSTITUTION. SOME MATTERS OF FACT.

THE article by Professor Whitman in the issue of SCIENCE for October 3d, entitled 'The Impending Crisis in the History of the Marine Biological Laboratory,' contains much that is excellent by way of statement of general principle, but raises certain questions of fact that should be clearly understood by the general scientific public. The discussion carried on during the negotiations with the Carnegie Institution turned largely on the proposition that the existing property of the laboratory should be transferred to the Carnegie Institution, and was especially concerned with the question whether, under the reorganization thus necessitated, the scientific independence and representative cooperative character of the laboratory would be surrendered.

As chairman of the executive committee of the laboratory during the course of the negotiations I ask attention to two principal points in regard to which Professor Whitman's letter creates, I think, a wrong impression concerning the action of our own trustees and those of the Carnegie Institution.

The first is contained in the following passage (p. 511):

"It is due to the trustees of the Carnegie Institution to say that the proposition to acquire the laboratory as a condition to supporting it did not originate with them. This is the humiliating side of the situation in which we now find ourselves. They were told that the laboratory was in dire financial distress, that some local western institution was machinating to get possession; in short, that there was an emergency requiring immediate action to save the institution. *They were asked on what terms they would consent to own and support it.*" (Italics mine.)

I desire to state that, by the insertion of the words 'to own' in the above passage, the form in which the matter was laid before the Carnegie Institution by our committee is changed in an essential particular. No such question was asked or suggested in any of the official correspondence, all of which passed through my hands; and if such a request or suggestion was privately made by anyone connected with the laboratory it was without the authorization, and without the knowledge of the executive committee. On the contrary, the opinion was expressed to the Carnegie trustees that 'An organization similar to the existing one would be preferable if compatible with adequate financial support' (quoted from a letter to Secretary Walcott dated March 8); and in communications addressed to President Gilman, Secretary Walcott and others the Carnegie trustees were only invited to offer suggestions as to 'the best practicable organization that would commend itself to the Carnegie Institution as an assurance of its national representative character' (quoted from the same letter to Secretary Walcott).

The suggestion that the Carnegie Institution should own the property of the laboratory first came to the Marine Biological Laboratory trustees from a subcommittee appointed by the Carnegie executive committee to consider and report upon the general proposition to support the laboratory; to the best of my knowledge and belief it originated with members of this subcommittee. It was based on the ground that a guarantee of *permanent and continuous* support, involving the purchase of land, erection and equipment of buildings, and the regular contribution of funds for running expenses, could only be promised the laboratory by placing the Carnegie trustees in a position of financial control and responsibility. The grounds for taking this position were fully and repeatedly explained to the representatives of the laboratory as an obvious necessity of good business management; and at no time during the negotiations was the least ground given for the suspicion that an unfair advantage was being taken of the emergency created by the financial difficulties of the laboratory. In the various discussions which took place the line was clearly drawn between financial control and scientific control.

The second point, therefore, to which attention is directed is the nature of the guarantee of scientific independence offered the laboratory by the Carnegie committee. From Professor Whitman's letter it might be inferred

that the only assurance of freedom of action lay in the personal statements of 'one or two of our trustees.' His meaning will doubtless be clear to those familiar with the basis of agreement, but as a statement to scientific men in general, who are not fully cognizant of the true situation, it is somewhat misleading. It is due alike to the Carnegie Institution and to the scientific public to state that *the entire scientific management of the laboratory, under the proposed arrangement, is placed in the hands of a representative board of scientific men*, the constitution, powers and functions of which are fully defined in a set of by-laws roughly drafted by our own representatives in consultation with those of the Carnegie Institution, submitted in writing to every member of our board of trustees, discussed and modified in subsequent meetings of conference committees, and finally adopted by unanimous vote of the board at their last meeting before action by the corporation. Nominated to the Carnegie trustees by members of the laboratory, and subject only to the limits of the appropriations made by the Carnegie Institution and of income from other sources, this board of managers is given entire control of the scientific management of the laboratory and its dependencies, and is by the by-laws constituted an advisory council to the Carnegie Institution. The only conditions limiting the action of this board were that it should include one representative of the Carnegie trustees, and that, in accordance with the terms of Mr. Carnegie's endowment, the Carnegie funds were not to be devoted to purposes of elementary instruction. To many of the trustees and members of the corporation it has seemed that this organization not only gave the scientific management the utmost freedom consistent with sound financial management, but by the constitution of the board as an advisory council to the institution gave it full opportunity to exert its influence in molding the future policy and development of the laboratory.

Whether the working plan thus outlined is adequate to the present needs and future development of the laboratory is no doubt open to discussion; and it may be stated on good authority that it will not be consummated, either in its present form or with modifications, without giving abundant further opportunity for such consideration. To maintain, however, that such a plan involves the abandonment of the principles of scientific representation, cooperation and freedom, would I think be at variance with the facts. That the laboratory has hitherto stood for these principles, and owes its success largely to their successful application, is undeniable; and that such cooperation has been possible in so large a measure is a lasting honor to American biologists. But before adopting a pessimistic view of the prospects of retaining the real substance of these much-to-be-desired blessings under the proposed Carnegie reorganization, it may be well to ask ourselves, in all candor, whether the history of the laboratory under its existing organization has left us above criticism.

Edmund B. Wilson,

Chairman of the Executive Committee of the Marine Biological Laboratory during the period of the negotiations with the Carnegie Institution.

THE COOLING OF GASES BY EXPANSION AND THE KINETIC THEORY.

In Science for August 22 there appears an abstract of a communication presented by Mr. Peter Fireman at the last meeting of the American Association, in which the cooling and heating effects in the classical experiment of Joule are referred to a sort of fractioning process of the slow and swift molecules. How rigorous a treatment he has given the subject I am unable to judge from the abstract, in which it is merely stated that, if a molecule enters the vacuum receiver at a high velocity, it will retain this velocity, while if a slower moving one enters, it will soon meet with a swifter one and exchange velocities with it. Just how the fractioning process occurs is not very clearly stated.

This same explanation, only in a much more complete form, was given by Natanson more than thirteen years ago. His treatment will be found in *Wiedemann's Annalen*, Vol. XXXVII., page 341.

R. W. Wood.

San Francisco,
September 8, 1902.

THE LAWS OF PHYSICS.

Professor C. R. Van Hise, in his excellent address on the training and work of a geologist (Science, August 29), criticises the spiritualistic views of Dr. A. R. Wallace (p. 333) on the ground that they show an ignorance of physical laws. If Professor Van Hise were more familiar with Dr. Wallace's writings, he would know that that naturalist is no mere biologist, but is well acquainted with the currently accepted laws of physics. If he should remain unconvinced of this, he could not say that Professors Crookes and Oliver Lodge, who hold similarly heterodox opinions, are not familiar with the principles of physics! It seems to me that Professor Van Hise might just as well have claimed that believers in magnetism were unacquainted with the laws of gravitation.

Some years ago I had the pleasure of discussing these matters with Dr. Wallace, and in my innocence I ventured to ask if he had sufficiently considered the laws of physics, and so forth. I can recall his smile as he said that of course he had considered them, and then went on to say that all phenomena were equally natural and in accordance with natural laws, only some had received a theoretical explanation, while others had not.

Dr. Wallace's views may or may not be absurd, but it seems clear that Professor Van Hise's criticism is without justice or validity.

T. D. A. Cockerell.

September 12, 1902.

LICHENS ON ROCKS.

To the Editor of Science: A few days ago, I visited a point along Chicago Creek near Idaho Springs, Colorado, and on examining the massive rock (gneiss) to ascertain the cause of the apparent weathering, I found the rocks literally covered with lichens of a uniform black color.

My observations were made in the vicinity of an abandoned tunnel site, in fact at the entrance, and while standing on the 'dump' my eye fell upon a piece of porphyritic rock which proved to be covered with arborescent figures closely resembling the imprint made by the lichens observed on the rocks above.

My first impressions were that the figures were simply those characteristic of 'dendrites,' but on further examination and reflection I discovered that the deposit on my specimen was upon the surface of a conchoidal fracture, the latter being evidently the result of a shot made prior to the removal of the rock from the fissure vein, and consequently the arborescence could not be the result of the infiltration of a mineral solution along a cleavage plane or fissure, which is generally supposed to be the cause of such deposits.

This conclusion was seemingly corroborated by a discovery made a few moments later on the opposite side of the cañon and at the base of another mountain. Here I found a magnificent hand specimen of porphyry which was evidently derived from a porphyry dyke which I know to be located several hundred feet above the creek. The entire surface of the specimen which had been exposed to the light was covered with beautiful forms of lichens of a brown, green, gray and black color, brown and green predominating.

The ground or main mass of the porphyry, consisting of a beautiful brown color in which were embedded the crystals of feldspar, led me to think that perhaps the differentiation in the color of the lichens was due to the mineral content of the underlying constituents of the rock; for the greater percentage of the browns were found growing in the brown main mass. Here was also evidenced their corrosive and etching effect upon the rock, the black lichens being evidently in a state of decomposition; their corrosive and penetrating effect was also quite apparent upon the massive rocks, resulting in beautiful arborescence similar to that found in the specimen first alluded to above.

I might add that the specimen was considerably mineralized, iron pyrites being disseminated throughout and readily observed by the naked eye. The presence of this accessory together with that of the essential oligoclase which might possibly contain manganese as one of its constituents leads me to ask, first, whether either one or both of these minerals could have influenced the color of the plant during life, second, whether the arborescence

of the specimen first alluded to was not entirely due to organic action.

Samuel T. Hensel.

BONES OF A MASTODON FOUND.

Laborers engaged in digging out muck have recently found in a swamp near Newburgh, N. Y., some of the bones of a mastodon. So far, there have been secured the lower jaw, with teeth in place; the teeth of the upper jaw; one tusk; eighteen ribs, or seven complete ones and fragments of four others; fifteen sections of the vertebræ; bones of the foot; and what is probably the skull, though in many small fragments. These bones laid at a depth varying from two to eight feet below the surface of the ground, a few in the muck, but most of them in the shell marl that underlies it. The swamp, about two acres in extent, is three quarters of a mile west of the Hudson River, one mile north of the northern limit of the city of Newburgh, and about one hundred and eighty feet above the river level. There is gently rising ground on the north and east, but directly west of the swamp the hills rise quite abruptly to a height of eighty or one hundred feet. The underlying rock beneath this muck bed appears to have a general slope to the southeast. The muck averages two feet in thickness, below which is marl, varying from a few inches to twelve feet in thickness, and under this, boulders and pebbles that form a solid bottom.

The bones found were scattered over an area about fifty by twenty feet, and in this respect they differ from those of the three mastodons found in Orange County in former years, and which were exhumed in almost the relative places they occupied when the animal was alive. The tusk found is curved, seven feet long and nearly seven inches in diameter at the root, and is in fair condition, though it showed signs of disintegration soon after removal from its resting place. Owing to the accumulation of water in the excavation, the progress of finding and removing the bones is very slow; but in a few days it may be possible to announce the finding of some other parts of the skeleton.

Reginald Gordon.

THE AMERICANIST CONGRESS IN NEW YORK.

The 13th session of the International Congress of Americanists will open at noon, Monday, October 20, and continue during the week, in the halls of the American Museum of Natural History. The hotel headquarters will be the Hotel Majestic. Lunch will be served daily at the Museum to all members. Thursday will be devoted to a trip through the parks, and visits to Columbia University, the Botanical Garden and Zoological Garden. More than eighty papers have already been offered to the Congress from nearly all the active students of Americanist subjects. The membership fee is three dollars which entitles one to all of the privileges of the meeting and to the volume of proceedings to be published later. The address of the general secretary is M. H. Saville, American Museum of Natural History, New York. It is expected that a large number of the anthropologists of the country will be present, and among the official foreign delegates are: Professor Dr. Seler, Professor Dr. von der Steiner, of Berlin, representing Prussia; Professor Dr. Stolfe, of Stockholm, Sweden; Professor Dr. Schmeltz, of Leiden, Holland; Professor Lejeal, of Paris, France; Alfredo Chavero Chavero, Dr. Leon, Francisco Belmar, of Mexico; Dr. Pittier, Dr. Ferraz, of Costa Rica. After the meeting the foreign guests will be given an excursion to Philadelphia, Washington, Pittsburg, Cincinnati and Chicago to visit the scientific and educational institutions of those cities. A visit will be made to the ancient fort in Ohio known as Fort Ancient. As this is the first meeting of the Americanist Congress in the United States it is hoped that there will be a large attendance of those interested in the work of this organization, namely, to bring together students of the archeology, ethnology and early history of the two Americas, and by the reading of papers and by discussions to advance knowledge of these subjects.

THE BRITISH AND AMERICAN ASSOCIATIONS.

In its report of the Belfast meeting of the British Association *Nature* says:

A noteworthy event of the meeting was the speech given by Professor C. S. Minot, President of the American Association, in which he invited members of the British Association to attend the meeting to be held early next January at Washington. Professor Minot said he had been directed by the council of his Association to express the hope that as many members as possible of the British Association would attend the Washington meeting. A vote had been passed to the effect that all members of the British Association would be received upon presenting themselves at the meetings in America as members of the American Association without further requirements. In future, as has already been announced in these columns, the annual meetings of the American Association will begin on the first Monday after Christmas and extend throughout the week. The scientific societies affiliated with the Association have agreed to this arrangement, and the universities have consented to the establishment of this 'Convocation Week,' in which the meetings of scientific societies are to be held. It is expected that the first meeting to be held next January under this rule will be the most important scientific gathering ever held in America. In the course of his remarks, Professor Minot said:

It was the duty, he believed, which they should all perform to attend these gatherings and take part in international intercourse. Many Americans had come to the British Association, and they had always been treated with the greatest hospitality. They arrived strangers and went away friends; they brought expectations, and took back realizations and a grateful memory. He asked for one moment in which to remind them of a new historic condition never existing in the world before. It was the first time that two great nations existed with a common speech, a common past, a common history; would they not therefore so work together that they might build up a common future? And for the scientific man this duty came first. Each nation was governed not by the government, but by the men of learning and above all by the universities. Nowhere, he believed, in the Anglo-Saxon world had science yet taken its place in the universities. Nowhere in the Anglo-Saxon world had the full value of scientific knowledge throughout the whole range of life, from the university down to every practical affair—nowhere, he said, had the full power of the world of science been established.

Professor Dewar, in replying on behalf of the Association, said:

They were all delighted to hear the kind invitation which had been extended to the members of the Association by their brother workers on the other side of the Atlantic. The great blunder we in the United Kingdom were perpetrating for many years past was in remaining ignorant of what was being done on the other side of the Atlantic. He had again and again said to manufacturers and those interested in industrial progress that if they would subsidize their chief officials by a donation which would enable them to spend their short holiday by going to see what could be seen during a three weeks' residence in the United States, to note how they economize time there, how a person could be transferred from place to place, the freedom with which one is allowed to see the great internal organization —if they did that they would be repaid onehundredfold. He did not know of anything that had occurred to himself personally which had affected him so much as a short visit which he had the honor of paying to America. Both in the universities and in applied industries it was a revelation to him, and he was sure it would be a personal gratification to every member of that association, and an entirely new revelation to them, if they took advantage of the invitation offered. He hoped some of the officials of the British Association would be present on the great occasion in Washington.

THE METRIC SYSTEM IN GREAT BRITAIN.

CONSUL-GENERAL H. CLAY EVANS sends to the Department of State from London, August 30, 1902, a letter from the secretary of the Decimal Association, showing the progress of efforts to have the metric system of weights and measures adopted in England. The letter says:

It has come to my knowledge that there is a considerable feeling in favor of the adoption of the metric weights and measures in the United States of America, and with this in mind, I am sure that you will be interested in information regarding the prospect of this country adopting metric weights and measures also.

I therefore venture to lay before you the following information: There are 290 members of the present House of Commons so thoroughly in accord with our aims that they have given me authority to publish their names as supporters. If we add to this the number of members of Parliament who would be influenced by a debate in the House of Commons to vote in our favor, we are convinced that we are now strong enough to carry a bill.

During the last four or five weeks, no less than sixty city, town, and county councils have passed resolutions to the effect that it is desirable that the reform should be made in the interest of commerce and education.

One of the most definite results, in fact, I think I may say, the most definite result, of the conference of the colonial premiers was the passing of a resolution in favor of the adoption of the metric weights and measures throughout the British Empire. This will have a most important result, and will render certain the early passing of a bill to give effect to those views.

All the chambers of commerce in this country, nearly all the school boards, the trades unions, and a great number of societies of various kinds have for a long time been active supporters of my association.

The attitude of our premier may be gathered from some remarks he made to the deputation which waited upon him in regard to this question in 1895. He said:

"If I may express my own opinion upon the merits of the case, there can be no doubt whatever that the judgment of the whole civilized world, not excluding the countries which still adhere to the antiquated systems under which we suffer, has long decided that the metric system is the only rational system."

SCIENTIFIC NOTES AND NEWS.

A COMMITTEE has been formed for the erection of a public memorial of the late Professor Virchow in Berlin, with Professor Waldeyer as chairman.

A MONUMENT, consisting of a pedestal and a bust by the sculptor, Marqueste, is to be erected in the Paris Museum of Natural History, in memory of Alphonse Milne-Edwards.

MR. WILLIAM BATESON, fellow of St. John's College, Cambridge, and author of important contributions to zoology, is at present in the United States.

DR. F. Y. EDGEWORTH, professor of political economy at Oxford University, known for his important contributions to statistics and mathematics, will give a course of lectures at Harvard University, beginning about the middle of the present month.

COL. H. A. YORKE, of the British Royal Engineer Army Corps, is at present in the United States, for the purpose of inspecting the electrical railway system.

MR. JAMES MOONEY, of the Bureau of Ethnology, recently returned from studies among the Kiowa Indians and expects to leave shortly to resume his work which will be continued through the coming winter. He is now engaged in the preparation of a set of models of Kiowa shields and tipis. Each of the latter is being made by the man who alone has a right to use it. The former are all by native artists working under direct instruction of the owner of the shield. Mr. Mooney is having a similar set of models of Cheyenne shields and tipis prepared for the Field Columbian Museum, Chicago.

PROFESSOR CHARLES E. BESSEY has been appointed by the University of Nebraska to be its delegates to the inaugural exercises of Chancellor Strong, of the University of Kansas, October 17.

PROFESSOR J. P. IDDINGS, professor of petrology in the University of Chicago, has been elected a Foreign Member of the Scientific Society of Christiania, Norway.

THE King of Italy has conferred the cross of a grand officer of the Italian Order of the Crown on Mr. G. Marconi.

MR. ANDREW CARNEGIE will be installed as rector of the University of St. Andrews on October 22. Dr. Andrew D. White will at the same time receive the degree of LL.D. Dr. White will also receive the degree of D.C.L. at Oxford, where he will attend the three hundredth anniversary of the Bodleian Library.

MR. A. R. RUGGLES, a graduate of Cornell University, has been elected assistant to the state entomologist of Minnesota.

MR. WILLIAM S. MYERS, until last year associate professor of chemistry at Rutgers College and now director of the Chilean Nitrate Works, has been elected a trustee of Rutgers College.

LIEUTENANT ROBERT E. PEARY has been advanced to the rank of commander.

PROFESSOR SAPPER, of Tübingen, has undertaken an expedition to study earthquakes in Guatemala and Martinique.

THE Harveian Oration before the Royal College of Physicians of London will be delivered by Dr. David Ferrier, F.R.S., on October 18.

AN association has been formed to buy the house in Nantucket in which Maria Mitchell, the astronomer, was born. It is proposed to place there her library and to establish a museum.

WE regret to note the death of M. Damour, the eminent French chemist, aged ninety-four years; of Dr. Theodor von Heldreich, director of the Botanical Gardens at Athens, at the age of eighty years; and of Professor O. G. Nordenström, professor at the Stockholm School of Mines.

IN connection with the recent death of Professor H. Wild, we learn that his widow, Madame R. von Wild (56 Englischviertel Zurich, Switzerland), is willing to sell her husband's large library, bearing chiefly on meteorology, magnetism, metrology and physics. These subjects are generally not well represented in American libraries, and we hope that Professor Wild's collection will be secured for the United States.—C. A.

OWING to the fact that the educational authorities of New Orleans found themselves unable to provide satisfactory hotel and other accommodations for the Department of Superintendence during the Mardi Gras festival, the executive committee of the department have, by authority of the action of the department at the Minneapolis meeting, changed the meeting to Cincinnati, Ohio, February 24, 25 and 26.

FOREIGN journals announce that a donation of 50,000 rupees has been made by the government of India to the Pasteur Institute of India at Kasauli, and the Punjab government has handed over to the central committee of the institute as a free gift Drumbar House at Kasauli for the accommodation of the poorer class of European and Eurasian patients, while Sir Charles Rivas has given 10,000 rupees to the institute for the years 1902–3; grants have also been made by the governments of Burma and the United Provinces of Agra and Oudh, and the chief commissioners of the Central Provinces and Assam.

Nature reports that the zoological station of Arcachon, under the direction of M. le Dr. F. Jolyet, professor of medicine in the University of Bordeaux, is now in full work, but that the laboratories are not fully occupied. A new subsidiary station has recently been opened at Guethary, a small bathing place near St. Jean de Luz, which is stated to have an excellent beach for dredging operations.

A NEW institute, built by the Danish government for the production of serum and for the prosecution of bacteriological research, was opened on September 9 at Copenhagen.

A THERAPEUTICAL society has been organized in Great Britain with Sir W. T. Thiselton-Dyer as the first president.

Nature states that part of an expedition for the survey of the Gold Coast has set sail from Liverpool. The remaining members of the expedition, numbering between thirty and forty, consisting of trained surveyors from the Ordnance Survey and surveyors from Queensland and New Zealand, will leave for West Africa on October 4.

THE medical inspectors last week excluded from the schools of New York City 6,524 children afflicted with contagious diseases.

A CIVIL service examination will be held on October 21, to fill the positions of irrigation engineer and assistant engineer or hydrographer under the Geological Survey at a salary of $1,000 to $2,000 per annum, according

to experience and results of examination. We may again call attention to the examination to be held on the same day for the position of aid in the Coast and Geodetic Survey, where fourteen vacancies are to be filled. Aids are appointed at a salary of $720 per year. The next step in the line of promotion is to the salary of $900 as aid, and thence to assistant at $1,200 and then upward by steps of $200 each. These statements of salary are misleading unless taken in connection with the fact that necessary traveling expenses incurred in the line of duty are paid by the government, and that in addition to his salary he is paid an allowance for subsistence to cover the ordinary living expenses while on field duty.

Nature gives the following comparison of the attendance at the Belfast meetings of the British Association in 1874 and 1902:

	1874.	1902.
Old Life Members	162	243
New Life Members	13	21
Old Annual Members	232	314
New Annual Members	85	84
Associates	817	647
Ladies	630	305
Foreign Members	12	6
	1951	1620

It will be noticed that there were more men of science in attendance this year than twenty-eight years ago, but fewer tickets were purchased by local citizens. *Nature* remarks, "It has been questioned whether this falling off, especially in the number of ladies' tickets, may not be ascribed in a considerable degree to the educational methods of Ireland and their effect on the tastes of those brought up under their influence within the last thirty years." The fact, however, probably is that in Great Britain, as in America, a meeting of the Association, as it becomes more important scientifically, becomes less interesting socially. It is becoming increasingly difficult to bridge the gap between the professional man of science and the amateur scientist.

The Bureau of Forestry has established a dendro-chemical laboratory in cooperation with the Bureau of Chemistry. The plans for the organization of the new laboratory were prepared by Dr. H. W. Wiley, chief of the Bureau of Chemistry, of the U. S. Department of Agriculture, and were approved by Secretary Wilson and Mr. Pinchot, chief of the Bureau of Forestry. Mr. Wm. H. Krug has been put in charge of this laboratory, which is the first of its kind in the United States, if not in the world.

A valuable work of reference to the publications on North American geography, geology, paleontology, petrology and mineralogy covering the last nine years of the century, from 1892 to 1900, inclusive, has recently been issued by the United States Geological Survey as Bulletins Nos. 188 and 189. These books of reference contain a full list of the papers, numbering over 6,500, on the above subjects which have appeared during the period; they are taken from nearly 200 different American and foreign publications. The papers cover a wide range of subjects, and for convenience are classified both by topics and by the names of the authors. The compilation is the work of F. B. Weeks, of the Geological Survey.

A course of nine lectures on science and travel has been arranged by the Field Columbian Museum, Chicago, for Saturday afternoons in October and November at 3 o'clock. The subjects, dates and lecturers are:

October 4, 'Past and Future of the South Appalachian Mountains,' Dr. J. A. Holmes, State Geologist, North Carolina.

October 11, 'The Salmon and Salmon Fisheries of Alaska,' Dr. Tarleton H. Bean, Chief of the Department of Fish and Fisheries, St. Louis Exposition, 1904.

October 18, 'Flying Reptiles,' Dr. S. W. Williston, Professor of Paleontology, University of Chicago.

October 25, 'Invisible Stars,' Professor Edwin B. Frost, Yerkes Observatory, University of Chicago.

November 1, 'The Insect Life of Ponds and Streams,' Dr. Jas. G. Needham, Lake Forest College.

November 8, 'A Naturalist's Visit to Cuba,' Dr. C. H. Eigenmann, Director, Biological Station, Bloomington, Indiana.

November 15, 'The Mythologic Age—The Indian and the Buffalo,' Dr. George A. Dorsey, Curator of Anthropology, Field Columbian Museum.

November 22, 'The Fishes of Mexico—A Study in Geographical Distribution,' Dr. S. E. Meek, Assistant Curator, Department of Zoology, Field Columbian Museum.

November 29, 'The Navaho,' Mr. C. L. Owen, Assistant Curator, Division of Archeology, Field Columbian Museum.

WE learn from the *British Medical Journal* that an Institute of Colonial Medicine has recently been established in Paris, which is open to foreign as well as to French medical practitioners. Courses of theoretical instruction and laboratory demonstrations will be given in the laboratories of the faculty of medicine, while clinical teaching will be given in the Hôpital d'Auteuil. The scheme of instruction comprises a course on bacteriological and hæmatological technique given by Professor Chantemesse; one on parasitology by Professor Blanchard; one on tropical surgery by Professor Le Dentu; one on tropical ophthalmology by Professor de Lapersonne; one on tropical pathology and hygiene by Professor Wurtz; and one on tropical skin diseases by Dr. Jeanselme. The director of the institute is Professor Brouardel; the dean, Professor Debove.

IT is stated in *Nature* that the following rewards are offered by the government of South Australia for the discovery and working within the state of a deposit or deposits of marketable mineral manure—500*l.* if found on crown lands; 250*l.* if found on freehold lands. It is stipulated (1) that the deposit is easily accessible and within a reasonable distance of a railway or seaport, and not within twenty-five miles of any discovery on account of which any bonus has been paid; (2) that the deposit is sufficiently abundant and is available at a price which will allow of it being remuneratively used for agricultural purposes; (3) that the product is of a good marketable quality, averaging not less than 40 per cent. of phosphate of lime. In the event of a phosphate of a lower average composition being discovered, it may be recommended that a portion of the reward be paid. Applications must reach the Minister for Agriculture, Adelaide, not later than December 31.

THE rapid progress which the U. S. Geological Survey is making in the topographic survey of New York, conducted in cooperation with the state, is indicated by a recent report of this work by Mr. H. M. Wilson, geographer in charge for the Geological Survey, to the Hon. E. A. Bond, state engineer and surveyor. Eight parties were in the field, engaged in the mapping of twenty different sections or 'quadrangles.' Among the sections mapped in whole or in part were the Hobart, Kingston, Gilboa, Orwell, Boonville, Carthage, and Highmarket quadrangles, which were mapped under the supervision of Topographer J. H. Jennings, with E. G. Hamilton as chief assistant. Other quadrangles in which topographic work was carried on were the Nineveh, Greene, Richmond, Copake, and Bainbridge, also the Wayland, Bethany, and Chautauqua, the work being in charge, respectively, of E. G. Hamilton, W. R. Harper, C. C. Bassett, A. H. Bumstead, A. C. Roberts, and Gilbert Young. On Long Island the Setauket quadrangle was partially completed by G. H. Guerdrum, topographer, assisted by G. S. Smith, topographer, and in the Adirondacks work was done on the St. Regis, Saranac Lake, and Long Lake quadrangles under George H. Guerdrum and G. S. Smith, topographers, and W. R. Harper, T. F. Slaughter, and J. M. Whitman, Jr., assistant topographers. The total result of the work of these parties was the mapping of 452 square miles and the running of 395 miles of spirit levels and 460 miles of road traverse. In addition to the above topographic work, three parties under Professor A. H. Thompson, geographer, and Messrs. E. L. McNair and Oscar Jones, topographers, were engaged in primary triangulation and traverse; they occupied eight stations, erected signals, and ran 63 miles of primary traverse. Topographic maps embodying the results of this and subsequent work of the season will be prepared during the coming fall and made available as soon as possible.

M. DE FONVIELLE informs *Nature* that M. Camille Pelletan, Minister of the French Marine and of the Colonies, has placed the *Epée*, a torpedo destroyer, 306 tons, 62 men, at the

disposal of Comte de la Vaulx for purposes of aeronautical manœuvres on the Mediterranean, with a new balloon. It may be remembered that last year Comte de la Vaulx tried to cross the Mediterranean from Toulon with a large balloon made captive by floating pieces of wood. The experiment, although interesting, proved a failure, owing to the wind blowing eastward. This year the experiments are likely to begin from Palavas, a point near the place where, in 1901, the trip ended. The *Epée* is to join the balloon there on September 10. The new balloon will carry in its car a propelling petroleum engine, which, however, will be used only in the second series of manœuvres. On Sunday, August 24, M. Heureux, a young and promising aeronaut, tried on a smaller scale similar performances in the Channel. He proved by an ascent at Dunkerque that a tug-boat can conduct a balloon against a strong wind. The balloon *Alcor* was sent up in the direction of the sea and for some time was lost to view in the clouds; but, after having run some miles, the valve was opened and the balloon descended close to the waves. M. Heureux dropped his cone-anchor and waited until a tug-boat, sent out especially from Dunkerque, threw a rope to the car, by which the balloon was tugged easily and reached Dunkerque fully inflated.

UNIVERSITY AND EDUCATIONAL NEWS.

S. W. Robinson, professor emeritus of mechanical engineering in the Ohio State University, has given $5,000 to that institution to endow a scholarship in engineering. Under the laws of Ohio this money goes into the state treasury, where it becomes a part of the irreducible debt of the state, and commands six per cent. interest, payable semi-annually.

Columbia University has purchased, with the fund given by Mr. Adolph Lewisohn, 50,000 dissertations presented for the doctorate at German Universities.

An institute of pedagogy, under the auspices of the Catholic University at Washington, has been opened in New York City.

M. A. Francois Monod has been appointed fellow by the French Department of Public Instruction to pursue his studies at Columbia University, and it is expected that another fellow will be appointed. Columbia University will in turn appoint two fellows to carry on researches in France. The student may study science or any subject that he may select.

The following appointments have been made in the zoological department of the University of Nebraska: Dr. Robert H. Wolcott, advanced to an assistant professorship; Mr. W. A. Willard (Harvard), who had charge of the biological work at Grinnell College last year, instructor, vice A. B. Lewis, resigned to continue graduate work in anthropology at Columbia University; Dr. R. S. Lillie, last year assistant in physiology, Harvard Medical School, instructor in physiology and histology; Mr. Geo. T. Hargitt, former assistant in biology, Syracuse University, fellow vice B. H. Ransom, who becomes assistant in the Hygienic Laboratory, Marine Hospital Service (Washington); Miss C. E. Stringer, scholar vice H. W. Graybill, who takes charge of natural science in the Columbus (Nebr.) High School; Mr. S. Fred Prince, formerly at the Missouri State Normal, as artist.

Dr. Raymond Pearl has been appointed instructor in zoology in the University of Michigan.

Superintendent Cooley, head of Chicago's public schools, has declined to accept the presidency of the University of the State of Washington, which had been tendered to him.

J. W. Miller, M.A., Ph.D. (Columbia), has been appointed instructor in mathematics and astronomy in Lehigh University.

Miss Daisy F. Bonnell, having resigned the fellowship in botany in the University of Nebraska in order to accept the position of assistant in biology in the Omaha High School, the vacancy has been filled by the appointment of Patrick J. O'Gara, B.Sc. (Nebraska, 1902), to a schlarship in botany, and George F. Miles, of the senior class, to the position of undergraduate assistant in botany.

Mr. H. W. Malcolm, M.A., B.Sc. (Aberdeen), has been appointed lecturer in physics in University College, Bristol.